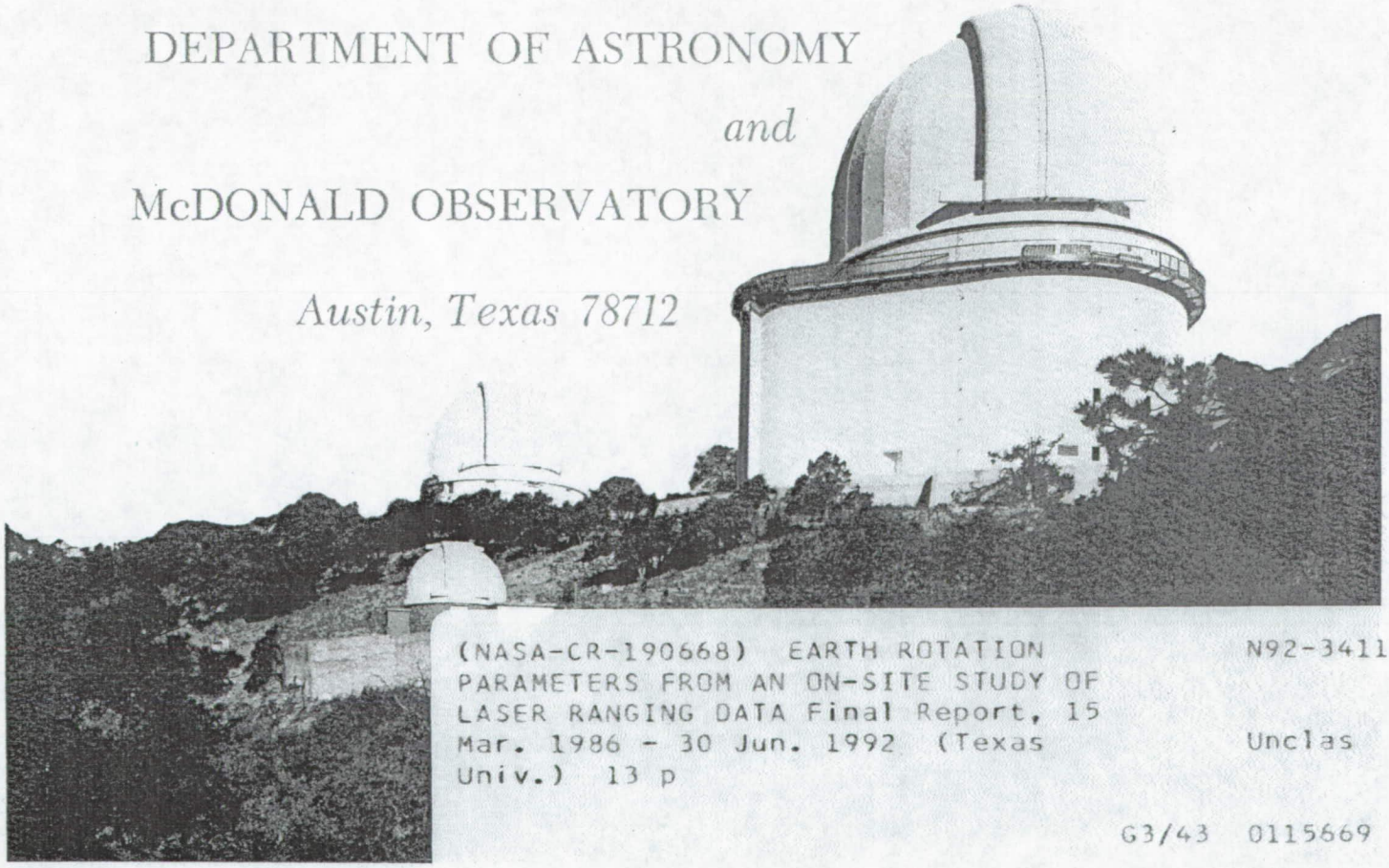
THE UNIVERSITY OF TEXAS AT AUSTIN

DEPARTMENT OF ASTRONOMY

and

McDONALD OBSERVATORY

Austin, Texas 78712



THE UNIVERSITY OF TEXAS AT AUSTIN

Earth Rotation Parameters from an On-Site Study of Laser Ranging Data

NASA Contract No. NAG5-754

Final Report

Peter J. Shelus, Principal Investigator

1986 March 15 - 1992 June 30

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Introduction

NASA Research Grant NASG 5-754 was originally awarded, through the Crustal Dynamics Project at Goddard Space Flight Center, to the McDonald Observatory, University of Texas at Austin for a one year period beginning 1986 March 15. With a number of supplements and extentions, our efforts continued through 1992 June 30. The scientific results that have been obtained during the more than 6 years of effort on this Grant have been extensive and have been cataloged in the regular semi-annual reports which have been submitted as a routine part of our activities. We believe that we have now brought this Grant to a cost efficient and satisfactory close.

Throughout the entire term of this Grant a multi-faceted effort had been maintained to achieve the following goals:

1. provide for state-of-the-art, on-site, near-real-time Earth orientation parameter determinations at levels of precision and accuracy commensurate with a "quick-look" type of an analysis, using the lunar laser ranging (LLR) data type from the McDonald Laser Ranging Station (MLRS) and other LLR facilities around the world;

2. create a state-of-the-art, highly transportable, LLR-based Earth orientation solution package, which could be easily implemented at LLR facilities other than the MLRS;

3. accommodate, within the routine MLRS lunar range prediction and Earth orientation data analysis software packages, the standard set of Jet Propulsion Laboratory (JPL) Solar System ephemerides, lunar librations, and Solar System partial derivatives;

4. examine, wherever possible, opportunities for the performance of state-of-the-art, on-site, joint, simultaneous, quick-look analysis for Earth orientation parameters, using both MLRS lunar and LAGEOS (and, perhaps, Etalon) ranging observations, as well as from multiple LLR station observations.

Excellent results had been obtained at all levels of effort and it can be said that all of these goals had been attained. The reader is referred to the complete series of our semi-annual reports for a full description of our evolving efforts under this Grant.

On-Site, Near-Real-Time UT-0 Determinations

As we have already mentioned above, the first goal of this Grant has been fully realized. An on-site, state-of-the-art, near-real-time Earth orientation analysis software system is in place and in routine operation at the MLRS (located at McDonald Observatory in far west Texas) and at the Department of Astronomy at the University of Texas at Austin. The relevant Earth orientation parameters (i.e., ΔUT0 and $\Delta\phi$) are routinely being supplied, on a weekly basis, in a quick-look, turn-around mode to the International Earth Rotation Service (IERS) at the Observatoire de Paris in Paris, France, the U. S. Naval Observatory (USNO) in Washington, DC, the Jet Propulsion Laboratory (JPL) in Pasadena, CA, and the Centre d'Etudes et de Recherches Geodynamiques et Astronomiques (CERGA) in Grasse, France via Internet E-mail. Also,

under this Grant, we were participating fully as an Observational Center as well as an Analysis Center for Lunar Laser Ranging within the International Earth Orientation Service (IERS).

A Transportable LLR Earth Orientation Analysis Package

The second goal of this Grant has also been realized. Highly transportable versions of our state-of-the-art, quick-look-data-based MLRS Earth orientation data analysis software package have been supplied by us to lunar laser ranging operations at the University of Hawaii/Institute for Astronomy LURE Observatory atop Mt. Haleakala on the island of Maui and to the Orroral Observatory laser ranging station in Orroral Valley, Australia. In addition, moderate efforts continued to be expended on moving the lunar prediction, filtering, normal pointing, and certain Earth orientation related software to CDP/Hewlett-Packard workstations computers, installed here in Austin as well as at the MLRS. This project was an unmitigated success. And, the process of "porting" this software to the new H-P computing environment has enhanced its portability significantly. All of this software can be moved to the LURE/H-P workstation at the LURE Observatory on Mt. Haleakala on the island of Maui, as well as to the one at Orroral Observatory in Australia, when suitable workstations become available at those sites.

Use of General JPL Solar System Ephemerides, Lunar Rotation Data Bases, and Solar System Partial Derivative Data Products

With respect to the third proposed goal of this Grant, the current level of agreement between the JPL results and our own indicates that our implementation of the JPL solar system ephemeris, lunar libration, and partial derivative material is more than adequate for predictive purposes. Further, efforts using the MIT-based Planetary Ephemeris Program (PEP) system, has shown us that the JPL material is an important "back-up" (for us) to PEP. The latest JPL ephemeris has also being implemented on the H-P workstation mentioned above. Therefore, we state that Proposed Goal # 3 has also been attained.

Lunar/LAGEOS and Multi-Station Earth Rotation Data Products

Goal # 4 has also been attained. At the close of our operations under this Grant, the LLR network is still not able to provide lunar data in a volume and density sufficient to determine, in and of itself, all three components of Earth orientation. As a part of the effort which had been expended under this contract, however, in using a UT/CSR LAGEOS polar motion data product, we were able to provide single station UT0 and variation of latitude estimations of the first quality for lunar data being gathered at the Maui, CERGA, McDonald, and other sites. Figure 1 illustrates the volume and density of this LLR Earth orientation data product, on a quarterly basis, throughout the duration of this Grant. Figure 2 attests to the quality of this data product through a long-term UT2R-TAI comparison with VLBI. The following summarizes the manner and the rationale under which this information has been extracted from the LLR data under this Grant.

The extraction of "quick-look" Earth orientation parameters from any set of laser ranging data requires the best possible (O-C) residuals. This requires that an excellent set of a priori Earth orientation series must be available. As stated above, we have used, as our present a

Figure 1: Lunar Network Statistics

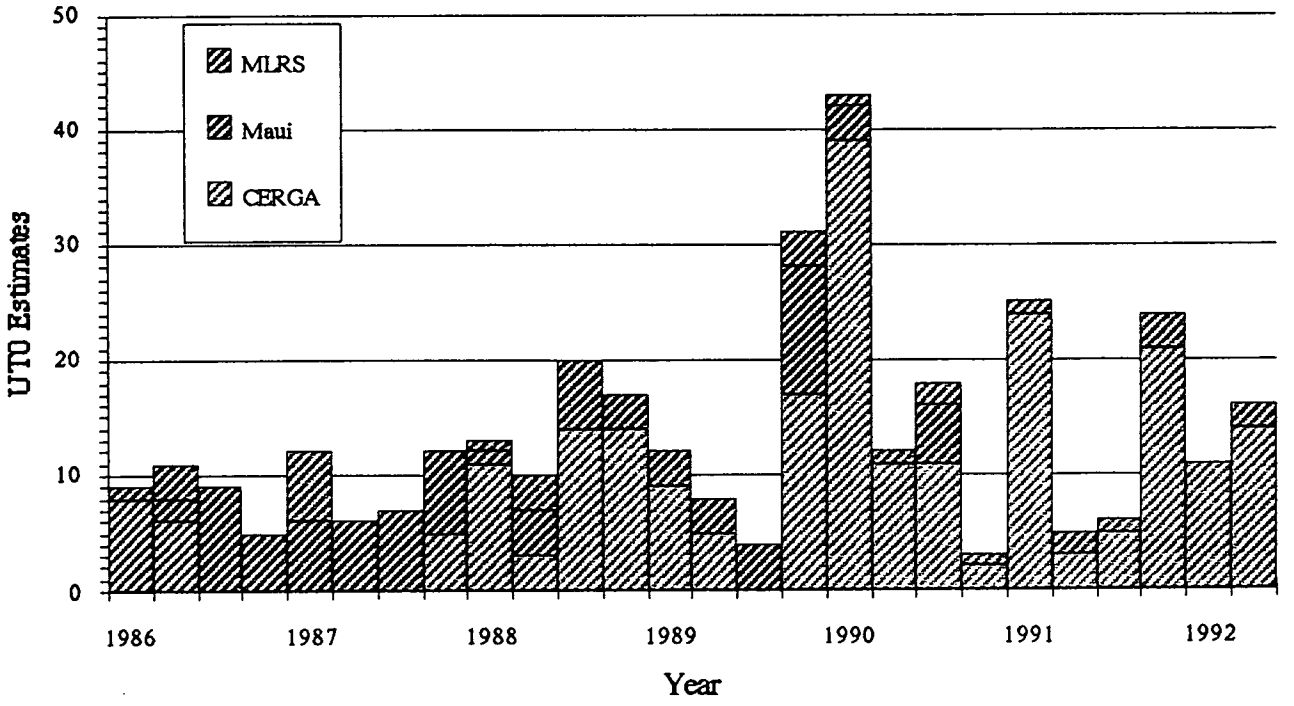
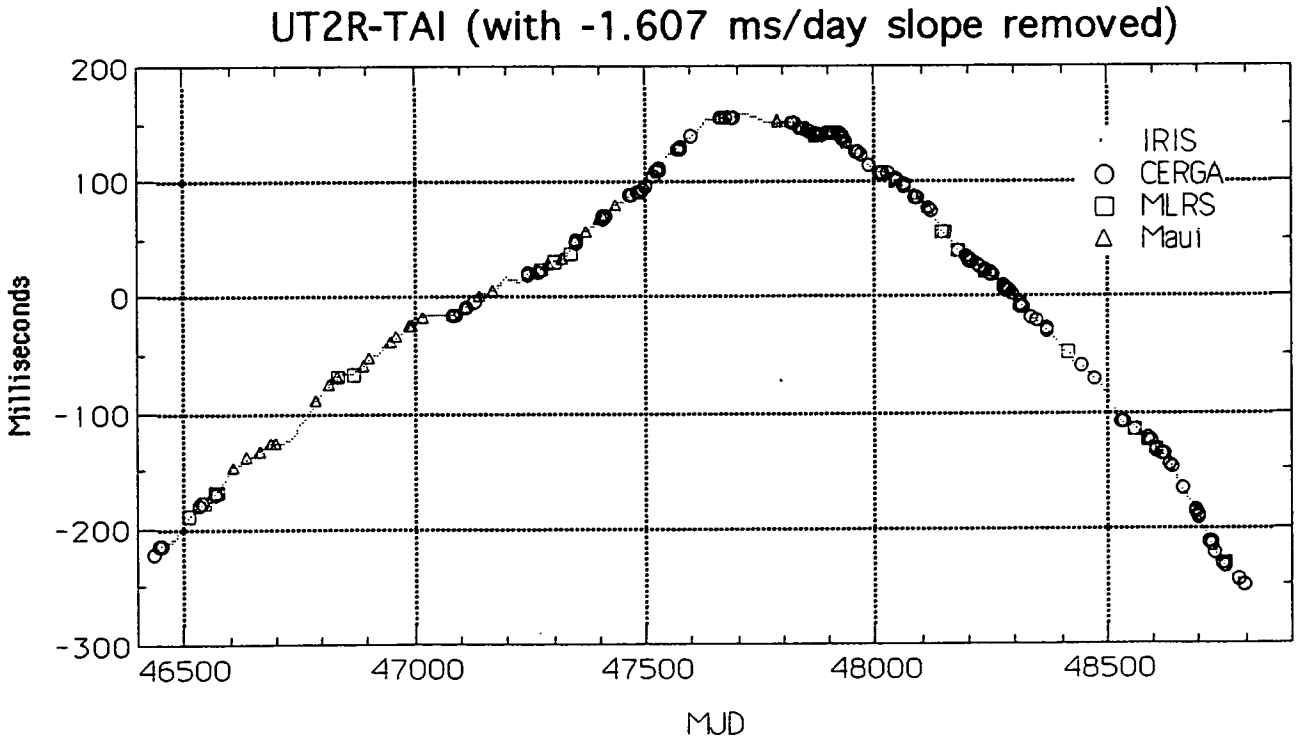


Figure 2



priori's, a set of Earth orientation series which were produced by the University of Texas Center for Space Research (UT/CSR). These UT/CSR LAGEOS reductions are capable of a completely independent determination of polar motion at the millisecond of arc level. They are also capable of the determination of short-period variations in Universal Time (UT) at the few tenths of a millisecond of time level. UT/CSR maintains a set of continuous and smoothed Earth orientation series back to 1976, and which are updated weekly. The only deficiency in these series is the stochastic, long-term drift in the node of the LAGEOS orbit. This drift is highly correlated with UT and causes a non-linear runoff in the UT/CSR UT series (which can be as large as 1 millisecond of time per month). This runoff has been controlled by UT/CSR's tying their UT series to the IRIS/VLBI UT series. This works well, except for the fact that the IRIS series are almost always more than a month old at the tie point.

The Universal Time computations, which were performed as a cooperative effort between this Crustal Dynamics Project Grant and NASA Contract NAS5-30942 (formerly NASA Contract NAS5-29404), were as follows. The station by station lunar data were first edited and re-weighted using an automated and objective scheme which identified suspected outliers. A follow-on procedure adjusted each observing station's assigned weight in an attempt to yield consistent distributions of the weighted residuals for all stations. The Massachusetts Institute of Technology (MIT) Planetary Ephemeris Program (PEP) was then used to estimate corrections to global parameters. In the main, MERIT standards were being used with constrained corrections to the constant of precession, obliquity of the ecliptic, and the 18.6 year, annual, semi-annual, and fortnightly nutation terms. Adjustments were made for the Earth-Moon barycenter orbit, the lunar orbit, and the lunar librations. We estimated third degree and order lunar gravitational potentials, the lunar love number, the lunar dissipation parameter, and the selenocentric retroreflector coordinates. Also estimated were piecewise linear splines to all three components of Earth orientation. Lastly, time delay biases, relative to MLRS, for CERGA and Maui were estimated. The node of the Earth-Moon barycenter orbit was fixed to tie the longitude of the celestial frame. The longitude of the terrestrial frame was tied by fixing the zero point of the CSR Earth orientation adjustments. The AM0-2 plate motion model was used without adjustment. As mentioned earlier, our a priori Earth orientation series came from UT/CSR.

Following the global solution, post-fit residuals were then analyzed in the usual fashion (e.g., Stolz et al.[1]) to determine daily corrections to Earth orientation. Such Earth orientation parameters from single station lunar laser ranging (LLR) data were derived by estimating the variation of latitude, $\Delta\phi$, and the change in UT0, ΔUT0. A minimum of three normal points for each station/reflector pair and at least 1.5 hours of lunar hour angle coverage was the criteria which had been routinely adopted for our daily UT estimations (although a very few exceptions to these criteria had been made in cases where it was deemed necessary). These estimates were provided to the IERS Rapid Service Sub-Bureau at the U. S. Naval Observatory in Washington, DC and to the Central Bureau of the IERS at the Observatoire de Paris in Paris, France

[1]Stolz, A. P., P. L. Bender, J. E. Faller, E. C. Silverberg, J. D. Mulholland, P. J. Shelus, J. G. Williams, W. E. Carter, D. G. Currie, W. M. Kaula, "Earth Rotation Measured by Lunar Laser Ranging", *Science*, **193**, 997-999, 1976.

as they became available (working to a weekly schedule). Copies of these results also went to the Jet Propulsion Laboratory in Pasadena, CA and to the Centre d'Etudes et de Recherches Geodynamiques et Astronomiques in Grasse, France. It is important to note that in the production of our Earth orientation products, we were able to see the UT/CSR UT runoff when using the LLR residuals. We provided this information to UT/CSR which should eventually allow them to apply a correction to their series in a time frame shorter than they can do with IRIS/VLBI results. In Table 1 we present those UT0-UTC estimates which were made in Austin during the course of the Grant.

Table 1.

MINIMUM NUMBER OF POINTS = 3, MINIMUM HOUR ANGLE COVERAGE = 1.5

YR	MO	DA	MJD	UT0-UTC (SEC)	S.D. (SEC)	STA	REF	NUM	DHA	PRE WRMS (NS)	POST WRMS (NS)	BIAS (NS)	S.D. (NS)
1986	1	4	46434.192789	0.31934	0.00034	CER	HAD	9	4.9	0.583	0.484	0.060	0.422
1986	1	16	46446.778641	0.30057	0.00031	CER	HAD	8	5.2	0.576	0.499	0.387	0.539
1986	1	17	46447.780844	0.29860	0.00040	CER	HAD	5	4.6	0.433	0.273	0.394	0.541
1986	1	17	46447.823633	0.29844	0.00038	CER	LK2	4	4.8	0.765	0.154	-0.514	0.735
1986	1	18	46448.887177	0.29675	0.00035	CER	HAD	7	2.8	0.408	0.327	0.573	0.953
1986	1	19	46449.877024	0.29609	0.00073	CER	HAD	3	2.4	1.306	0.916	0.471	1.257
1986	1	20	46450.839566	0.29389	0.00022	CER	HAD	9	10.3	0.701	0.453	0.160	0.484
1986	1	20	46450.920001	0.29477	0.00031	CER	FRM	5	6.5	1.023	0.484	0.529	0.576
1986	3	23	46512.113507	0.20030	0.00021	MLR	HAD	3	4.8	0.135	0.120	-0.117	0.459
1986	4	13	46533.826543	0.17382	0.00051	CER	HAD	5	1.5	0.379	0.194	-0.157	1.677
1986	4	18	46538.841449	0.16821	0.00020	CER	HAD	12	8.7	0.562	0.527	-0.161	0.526
1986	4	19	46539.873982	0.16655	0.00026	CER	HAD	10	6.6	0.821	0.750	0.399	0.420
1986	4	22	46542.237729	0.15274	0.00020	MLR	HAD	3	5.9	0.256	0.079	0.051	0.350
1986	5	16	46566.844916	0.12665	0.00073	CER	HAD	4	1.9	0.702	0.598	-1.140	1.455
1986	5	17	46567.798537	0.12549	0.00094	CER	HAD	4	2.3	0.589	0.510	-0.417	0.618
1986	5	18	46568.839932	0.12350	0.00033	CER	HAD	7	5.0	0.319	0.298	0.148	0.438
1986	5	20	46570.147594	0.10877	0.00025	MLR	HAD	3	4.6	0.128	0.080	0.125	0.322
1986	5	21	46571.200918	0.10672	0.00020	MLR	HAD	3	4.8	0.255	0.122	0.253	0.303
1986	6	28	46609.600098	0.06639	0.00052	HAL	HAD	5	1.9	0.351	0.217	-0.691	0.805
1986	6	29	46610.596039	0.06554	0.00041	HAL	HAD	6	2.1	0.258	0.114	0.049	0.991
1986	7	28	46639.579245	0.04468	0.00015	HAL	HAD	8	3.8	0.286	0.200	-0.154	0.400
1986	8	24	46666.469158	0.02526	0.00015	HAL	HAD	5	3.8	0.376	0.292	-0.304	0.539
1986	9	15	46688.403648	0.00663	0.00029	HAL	HAD	7	3.7	0.417	0.269	0.246	0.411
1986	9	25	46698.535831	-.00850	0.00045	HAL	HAD	4	4.9	0.663	0.405	-0.498	0.425
1986	12	23	46787.596904	-.13470	0.00059	HAL	HAD	3	2.1	0.504	0.371	0.314	0.919
1987	1	21	46816.629494	-.17184	0.00023	HAL	HAD	6	5.8	0.343	0.329	-0.040	0.326
1987	1	22	46817.628338	-.17382	0.00047	HAL	HAD	3	3.5	0.511	0.110	-0.662	0.567
1987	2	8	46834.122199	-.19585	0.00030	MLR	HAD	3	3.6	0.190	0.102	-0.254	0.445
1987	2	8	46834.381263	-.19642	0.00231	HAL	HAD	4	2.9	0.188	0.024	0.313	2.172
1987	2	10	46836.474111	-.19834	0.00453	HAL	HAD	3	2.1	0.204	0.007	0.391	4.460
1987	3	12	46866.240691	-.24801	0.00021	MLR	HAD	3	4.7	0.113	0.095	0.043	0.384
1987	3	13	46867.143801	-.24935	0.00024	MLR	HAD	3	2.6	0.146	0.061	0.070	0.522
1987	4	8	46893.336909	-.29417	0.00058	HAL	HAD	6	5.1	0.295	0.253	0.071	0.222
1987	4	20	46905.625205	-.31374	0.00083	HAL	HAD	3	1.8	0.424	0.219	0.782	0.921
1987	6	6	46952.361126	-.37959	0.00033	HAL	HAD	5	2.5	0.195	0.109	0.364	0.904
1987	6	17	46963.581179	-.39228	0.00031	HAL	HAD	6	3.2	0.388	0.158	-0.021	0.522
1987	7	16	46992.589920	-.41390	0.00021	HAL	HAD	5	3.6	0.312	0.194	0.168	0.276
1987	7	17	46993.666303	-.41534	0.00012	HAL	HAD	9	5.7	0.272	0.220	0.127	0.200
1987	8	13	47020.455314	-.43029	0.00016	HAL	HAD	3	2.5	0.114	0.086	-0.153	0.572
1987	8	14	47021.603567	-.43148	0.00008	HAL	HAD	9	7.2	0.084	0.060	0.075	0.218
1987	10	12	47080.577835	-.50860	0.00031	HAL	HAD	6	4.0	0.241	0.102	-0.160	0.267
1987	10	13	47081.071724	-.48356	0.00022	CER	LK2	8	4.1	0.414	0.277	-0.102	0.397
1987	10	14	47082.122120	-.48459	0.00036	CER	LK2	3	4.8	0.347	0.113	-0.031	0.468
1987	10	18	47086.186635	-.49022	0.00023	CER	HAD	6	2.2	0.452	0.265	0.804	0.913

1987	11	10	47109.466109	-.55680	0.00111	HAL	HAD	4	3.3	0.222	0.068	-0.427 1.091
1987	11	11	47110.505918	-.55771	0.00163	HAL	HAD	5	3.6	0.088	0.033	0.140 1.280
1987	11	12	47111.542962	-.55961	0.00074	HAL	HAD	4	2.3	0.023	0.002	-0.024 0.278
1987	11	15	47114.182093	-.53524	0.00044	CER	HAD	6	2.8	0.182	0.096	-0.330 0.780
1987	11	28	47127.845290	-.55725	0.00042	CER	FRM	8	3.8	0.585	0.231	-1.047 0.598
1987	12	11	47140.579751	-.60895	0.00016	HAL	HAD	5	5.0	0.103	0.040	-0.107 0.315
1988	1	9	47169.598492	0.34334	0.00037	HAL	HAD	4	2.8	0.101	0.097	-0.013 0.345
1988	3	22	47242.782278	0.25880	0.00014	CER	HAD	6	2.3	0.096	0.049	0.113 0.509
1988	3	23	47243.685924	0.25790	0.00026	CER	HAD	10	4.8	0.193	0.155	0.109 0.186
1988	3	23	47243.713140	0.25789	0.00061	CER	FRM	3	2.3	0.172	0.087	-0.049 0.471
1988	3	24	47244.834809	0.25633	0.00024	CER	FRM	3	2.3	0.111	0.036	0.053 0.651
1988	3	24	47244.842061	0.25635	0.00016	CER	HAD	4	3.5	0.135	0.059	0.021 0.373
1988	3	26	47246.833691	0.25400	0.00027	CER	FRM	4	5.4	0.286	0.103	0.134 0.383
1988	3	26	47246.840462	0.25382	0.00016	CER	HAD	7	5.5	0.138	0.103	0.022 0.219
1988	3	26	47246.864432	0.25390	0.00029	CER	TRA	3	4.2	0.257	0.157	-0.050 0.428
1988	3	27	47247.844219	0.25242	0.00021	CER	TRA	7	5.3	0.107	0.087	0.079 0.267
1988	3	27	47247.847305	0.25238	0.00018	CER	HAD	10	5.4	0.230	0.154	0.213 0.191
1988	3	27	47247.865807	0.25243	0.00028	CER	FRM	5	4.2	0.293	0.287	0.030 0.327
1988	4	8	47259.646369	0.19264	0.00037	HAL	HAD	5	3.6	0.323	0.144	0.161 0.334
1988	4	14	47265.389383	0.21611	0.00056	CER	HAD	5	3.2	0.439	0.371	-0.252 0.417
1988	4	22	47273.824461	0.20015	0.00025	CER	HAD	5	2.8	0.640	0.150	-0.495 0.574
1988	4	22	47273.848531	0.20015	0.00025	CER	FRM	3	1.9	0.554	0.082	-0.410 0.996
1988	4	24	47275.135911	0.16441	0.00030	TLR	HAD	3	2.1	0.488	0.025	-0.004 0.590
1988	5	8	47289.634372	0.14152	0.00042	HAL	HAD	5	2.5	0.235	0.091	0.094 0.469
1988	5	24	47305.118817	0.11629	0.00032	TLR	HAD	3	2.5	0.317	0.126	-0.020 0.516
1988	6	5	47317.633414	0.10054	0.00049	HAL	HAD	3	2.1	0.232	0.027	-0.230 0.302
1988	6	6	47318.600762	0.09895	0.00019	HAL	HAD	7	4.2	0.210	0.077	-0.267 0.330
1988	6	23	47335.085606	0.08345	0.00046	TLR	HAD	3	2.7	0.355	0.160	-0.036 0.431
1988	7	5	47347.199529	0.10393	0.00065	CER	HAD	3	1.9	0.191	0.046	-0.199 0.326
1988	7	6	47348.161535	0.10277	0.00023	CER	HAD	6	3.6	0.221	0.126	-0.186 0.240
1988	7	6	47348.607974	0.07879	0.00048	HAL	HAD	4	1.7	0.171	0.099	-0.181 0.849
1988	7	7	47349.128158	0.10165	0.00015	CER	HAD	6	4.5	0.201	0.050	-0.102 0.363
1988	7	7	47349.140743	0.10204	0.00029	CER	TRA	3	3.5	0.596	0.171	-0.359 0.542
1988	7	7	47349.147020	0.10185	0.00042	CER	FRM	3	2.4	0.238	0.095	-0.183 0.683
1988	7	31	47373.571772	0.06810	0.00048	HAL	HAD	3	2.0	0.390	0.042	-0.241 0.493
1988	8	1	47374.553046	0.06694	0.00026	HAL	HAD	3	4.1	0.272	0.070	-0.264 0.336
1988	8	30	47403.483365	0.04967	0.00027	HAL	HAD	3	3.2	0.591	0.062	0.146 0.536
1988	9	1	47405.187848	0.06215	0.00035	CER	HAD	5	2.7	0.209	0.056	0.302 0.252
1988	9	1	47405.193084	0.06201	0.00071	CER	TRA	3	1.7	0.162	0.028	0.110 0.490
1988	9	2	47406.345404	0.06159	0.00011	CER	HAD	7	2.2	0.105	0.053	0.210 0.547
1988	9	2	47406.610101	0.04777	0.00045	HAL	HAD	3	3.6	0.339	0.096	-0.140 0.371
1988	9	4	47408.118904	0.06086	0.00012	CER	HAD	8	6.0	0.189	0.171	0.113 0.216
1988	9	5	47409.132914	0.06060	0.00012	CER	HAD	7	4.5	0.216	0.083	0.148 0.260
1988	9	5	47409.140439	0.06068	0.00016	CER	FRM	4	3.2	0.262	0.056	0.054 0.458
1988	9	5	47409.143360	0.06063	0.00021	CER	LK2	3	2.1	0.197	0.090	0.057 0.841
1988	9	5	47409.154821	0.06054	0.00018	CER	TRA	4	3.1	0.100	0.062	0.127 0.536
1988	9	7	47411.181678	0.05953	0.00014	CER	HAD	4	1.7	0.191	0.165	-0.003 0.875
1988	10	2	47436.572529	0.01891	0.00096	HAL	HAD	5	4.2	0.223	0.133	0.052 0.884
1988	11	2	47467.287519	-.01567	0.00021	CER	HAD	4	4.2	0.175	0.064	0.183 0.294
1988	11	5	47470.220269	-.02081	0.00037	CER	HAD	6	2.0	0.107	0.089	0.055 0.816
1988	11	16	47481.777035	-.03809	0.00026	CER	HAD	5	3.8	0.351	0.216	0.205 0.316
1988	11	20	47485.994526	-.04745	0.00028	CER	HAD	6	2.2	0.180	0.099	0.234 0.653
1988	11	29	47494.286825	-.05831	0.00031	CER	HAD	7	2.5	0.315	0.130	-0.266 0.647
1988	12	3	47498.194804	-.06523	0.00041	CER	HAD	5	3.0	0.128	0.081	0.028 0.631
1988	12	20	47515.894315	-.08777	0.00008	CER	HAD	21	9.3	0.289	0.180	0.124 0.170
1988	12	20	47515.943620	-.08753	0.00025	CER	FRM	3	6.3	0.211	0.049	0.261 0.594
1988	12	29	47524.266025	-.09378	0.00021	CER	HAD	8	3.1	0.071	0.038	-0.111 0.336
1988	12	30	47525.260732	-.09514	0.00018	CER	HAD	11	4.4	0.157	0.152	-0.073 0.212
1988	12	31	47526.217145	-.09663	0.00051	CER	LK2	4	2.7	0.102	0.042	-0.028 0.319
1988	12	31	47526.218365	-.09647	0.00012	CER	HAD	13	6.6	0.129	0.076	-0.108 0.161
1988	12	31	47526.222661	-.09663	0.00024	CER	TRA	6	5.6	0.525	0.115	-0.559 0.253
1988	12	31	47526.252600	-.09657	0.00036	CER	FRM	4	3.7	0.370	0.069	-0.377 0.319
1989	1	1	47527.199356	-.09775	0.00027	CER	HAD	5	3.9	0.145	0.090	-0.102 0.298
1989	1	1	47527.243613	-.09786	0.00048	CER	FRM	3	3.2	0.536	0.011	-0.564 0.370

1989	2	9	47566.769503	-.14461	0.00040	CER	HAD	6	1.5	0.235	0.111	-0.265 1.538
1989	2	11	47568.836609	-.14860	0.00023	CER	HAD	4	2.9	0.233	0.040	-0.264 0.863
1989	2	14	47571.867011	-.15179	0.00067	CER	HAD	4	1.7	0.485	0.038	-0.610 0.767
1989	2	16	47573.880274	-.15308	0.00012	CER	HAD	13	8.3	0.258	0.214	-0.125 0.230
1989	3	11	47596.797274	-.18565	0.00014	CER	HAD	4	3.3	0.159	0.096	-0.114 0.548
1989	3	12	47597.828183	-.18729	0.00016	CER	HAD	5	2.7	0.099	0.097	-0.071 0.766
1989	3	13	47598.782547	-.18855	0.00035	CER	HAD	7	3.1	0.088	0.074	0.050 0.437
1989	5	13	47659.316935	-.33044	0.00017	HAL	HAD	6	3.5	0.315	0.067	0.340 0.479
1989	5	13	47659.870095	-.28933	0.00022	CER	HAD	9	3.8	0.184	0.129	0.322 0.383
1989	5	15	47661.873931	-.29326	0.00029	CER	HAD	8	3.9	0.223	0.077	0.248 0.306
1989	5	16	47662.293765	-.33607	0.00050	HAL	HAD	4	2.2	0.288	0.103	0.275 0.312
1989	5	27	47673.561171	-.35312	0.00066	HAL	HAD	5	1.6	0.300	0.102	-0.340 1.399
1989	5	28	47674.254065	-.31363	0.00032	CER	HAD	7	3.1	0.150	0.137	0.017 0.221
1989	6	8	47685.835568	-.33249	0.00022	CER	HAD	5	1.7	0.563	0.108	-0.156 1.408
1989	6	11	47688.877842	-.33774	0.00044	CER	HAD	5	2.3	0.198	0.107	0.008 1.041
1989	9	19	47788.486323	-.47834	0.00027	HAL	HAD	12	5.6	0.085	0.084	0.010 0.158
1989	9	20	47789.553080	-.47952	0.00036	HAL	HAD	9	3.6	0.148	0.081	-0.062 0.312
1989	9	21	47790.510220	-.48051	0.00237	HAL	HAD	7	2.4	0.112	0.047	-0.088 2.341
1989	10	18	47817.190120	-.51450	0.00009	CER	HAD	17	7.3	0.147	0.130	0.063 0.174
1989	10	18	47817.544428	-.52383	0.00033	HAL	HAD	4	3.1	0.136	0.088	0.052 0.251
1989	10	19	47818.183692	-.51612	0.00029	CER	HAD	9	3.1	0.133	0.093	-0.086 0.237
1989	10	19	47818.574045	-.52562	0.00034	HAL	HAD	5	3.8	0.152	0.062	0.111 0.289
1989	10	20	47819.200346	-.51815	0.00013	CER	HAD	13	5.6	0.249	0.158	-0.230 0.165
1989	10	21	47820.597128	-.52941	0.00104	HAL	HAD	6	2.7	0.228	0.064	-0.051 0.503
1989	10	22	47821.154816	-.52205	0.00044	CER	LK2	3	2.7	0.082	0.041	-0.142 0.777
1989	10	22	47821.211020	-.52200	0.00020	CER	TRA	4	6.7	0.222	0.130	0.279 0.346
1989	10	22	47821.231556	-.52215	0.00009	CER	HAD	14	8.5	0.149	0.145	-0.002 0.158
1989	10	22	47821.311253	-.52221	0.00028	CER	FRM	6	4.3	0.163	0.137	-0.004 0.324
1989	11	7	47837.771553	-.55696	0.00077	CER	HAD	3	1.7	0.069	0.037	-0.041 0.289
1989	11	8	47838.336168	-.56489	0.00066	HAL	HAD	4	1.6	0.184	0.062	0.226 1.213
1989	11	8	47838.808888	-.55962	0.00059	CER	HAD	5	2.2	0.181	0.087	-0.155 0.245
1989	11	9	47839.148412	-.56658	0.00038	TLR	HAD	3	3.8	0.424	0.203	-0.459 0.413
1989	11	9	47839.371552	-.56743	0.00055	HAL	HAD	3	1.9	0.256	0.038	-0.173 1.068
1989	11	10	47840.170868	-.56952	0.00027	TLR	HAD	3	4.7	0.326	0.051	-0.284 0.396
1989	11	11	47841.005471	-.56586	0.00014	CER	HAD	9	4.0	0.204	0.151	0.017 0.337
1989	11	20	47850.603742	-.59190	0.00030	HAL	HAD	3	3.1	0.278	0.155	0.388 0.638
1989	11	23	47853.238809	-.59221	0.00028	CER	HAD	5	3.2	0.185	0.055	-0.072 0.391
1989	11	23	47853.256090	-.59223	0.00055	CER	TRA	3	2.5	0.321	0.056	0.179 0.572
1989	12	6	47866.320020	-.62583	0.00029	HAL	HAD	4	3.1	1.116	0.057	0.183 0.799
1989	12	7	47867.746133	-.62204	0.00030	CER	HAD	5	3.1	0.393	0.052	-0.041 0.241
1989	12	8	47868.354017	-.63126	0.00024	HAL	HAD	5	2.3	0.372	0.165	-0.178 0.623
1989	12	8	47868.850139	-.62462	0.00017	CER	HAD	7	4.7	0.383	0.098	-0.181 0.193
1989	12	8	47868.888157	-.62488	0.00027	CER	FRM	4	4.2	0.277	0.113	-0.302 0.351
1989	12	9	47869.216362	-.63019	0.00020	TLR	HAD	3	5.0	0.690	0.248	-0.597 0.444
1989	12	9	47869.823668	-.62696	0.00018	CER	HAD	8	4.9	0.113	0.045	-0.010 0.170
1989	12	20	47880.222834	-.64461	0.00035	CER	HAD	4	3.6	0.198	0.039	-0.198 0.245
1990	1	3	47894.812931	0.33233	0.00020	CER	HAD	5	4.7	0.290	0.138	-0.467 0.391
1990	1	4	47895.798312	0.33015	0.00013	CER	HAD	14	6.4	0.078	0.077	-0.009 0.171
1990	1	4	47895.831997	0.33005	0.00038	CER	FRM	3	3.2	0.069	0.044	-0.031 0.714
1990	1	5	47896.741037	0.32843	0.00014	CER	HAD	10	6.8	0.145	0.055	0.022 0.198
1990	1	5	47896.767998	0.32867	0.00045	CER	TRA	3	2.9	0.366	0.067	-0.256 0.317
1990	1	7	47898.926150	0.32495	0.00009	CER	HAD	21	9.0	0.220	0.171	0.168 0.169
1990	1	14	47905.007266	0.31707	0.00051	CER	TRA	3	2.3	0.230	0.001	-0.401 0.689
1990	1	14	47905.048678	0.31734	0.00008	CER	HAD	20	8.8	0.311	0.134	-0.069 0.146
1990	1	15	47906.128386	0.31542	0.00013	CER	HAD	8	7.6	0.205	0.139	-0.039 0.274
1990	1	16	47907.124750	0.31361	0.00009	CER	HAD	12	8.2	0.142	0.137	-0.032 0.160
1990	1	16	47907.173211	0.31361	0.00023	CER	FRM	4	5.5	0.161	0.118	-0.079 0.301
1990	1	16	47907.176965	0.31346	0.00019	CER	TRA	6	6.6	0.306	0.119	0.364 0.288
1990	1	17	47908.191003	0.31175	0.00017	CER	HAD	8	6.1	0.108	0.106	-0.019 0.209
1990	1	18	47909.153580	0.31023	0.00023	CER	HAD	6	4.2	0.081	0.076	-0.004 0.249
1990	1	18	47909.161614	0.31023	0.00032	CER	TRA	4	3.8	0.192	0.096	0.214 0.292
1990	1	19	47910.225664	0.30850	0.00028	CER	HAD	8	4.0	0.146	0.102	-0.094 0.186
1990	1	30	47921.748621	0.29082	0.00025	CER	HAD	7	3.0	0.232	0.126	-0.663 0.590
1990	1	30	47921.759060	0.29080	0.00037	CER	LK2	4	2.4	0.433	0.122	-0.022 1.142

1990	2	2	47924.824082	0.28302	0.00019	CER	HAD	5	5.8	0.168	0.082	-0.027	0.331
1990	2	3	47925.915065	0.28085	0.00012	CER	HAD	7	2.9	0.227	0.067	0.354	0.454
1990	2	4	47926.890102	0.27911	0.00013	CER	TRA	9	6.3	0.182	0.155	0.040	0.231
1990	2	4	47926.911648	0.27902	0.00009	CER	HAD	11	7.8	0.217	0.086	0.078	0.161
1990	2	4	47926.931536	0.27917	0.00011	CER	FRM	9	7.1	0.208	0.089	0.312	0.250
1990	2	5	47927.928705	0.27736	0.00010	CER	HAD	12	9.7	0.169	0.158	0.079	0.216
1990	2	5	47927.976423	0.27740	0.00014	CER	FRM	6	8.1	0.388	0.326	0.282	0.429
1990	2	6	47928.021518	0.27721	0.00019	CER	TRA	3	1.6	0.274	0.274	-0.049	0.989
1990	2	7	47929.006995	0.27535	0.00016	CER	HAD	5	4.5	0.229	0.127	-0.124	0.345
1990	2	9	47931.848227	0.26925	0.00031	CER	HAD	7	1.7	0.117	0.033	-0.672	1.147
1990	2	14	47936.613089	0.23535	0.00029	HAL	HAD	4	3.9	0.579	0.171	-0.483	0.354
1990	3	5	47955.793170	0.22183	0.00011	CER	HAD	9	10.9	0.403	0.346	-0.320	0.272
1990	3	6	47956.876746	0.22005	0.00015	CER	HAD	8	7.0	0.131	0.078	-0.054	0.213
1990	3	6	47956.878514	0.21991	0.00034	CER	TRA	3	3.4	0.205	0.064	0.203	0.383
1990	3	6	47956.955578	0.22031	0.00021	CER	FRM	4	3.8	0.433	0.116	-0.001	0.497
1990	3	7	47957.826087	0.21822	0.00049	CER	TRA	3	2.6	0.410	0.099	0.306	0.445
1990	3	7	47957.834920	0.21844	0.00013	CER	HAD	9	9.4	0.336	0.337	0.036	0.237
1990	3	9	47959.847151	0.21423	0.00026	CER	HAD	4	3.6	0.176	0.043	-0.243	0.446
1990	3	16	47966.121938	0.20051	0.00041	CER	HAD	5	3.6	0.623	0.184	0.636	0.260
1990	4	1	47982.848200	0.16338	0.00012	CER	HAD	6	3.3	0.241	0.066	-0.143	0.350
1990	4	1	47982.905098	0.16309	0.00026	CER	FRM	3	3.1	0.747	0.138	0.346	0.679
1990	4	28	48009.823830	0.10710	0.00027	CER	HAD	3	5.0	0.375	0.032	0.221	0.448
1990	4	30	48011.877726	0.10417	0.00015	CER	HAD	4	3.5	0.489	0.105	-0.404	0.527
1990	5	3	48014.883328	0.09879	0.00031	CER	HAD	5	3.8	0.742	0.112	-1.105	0.442
1990	5	4	48015.913937	0.09638	0.00031	CER	HAD	4	3.1	0.584	0.086	-0.490	0.428
1990	5	5	48016.905290	0.09440	0.00028	CER	HAD	5	4.7	0.190	0.079	0.061	0.338
1990	5	18	48029.161878	0.07476	0.00045	CER	HAD	6	2.2	0.282	0.093	0.440	0.678
1990	5	30	48041.843419	0.04926	0.00036	CER	HAD	4	2.0	0.337	0.061	-0.858	0.844
1990	5	31	48042.842267	0.04715	0.00055	CER	HAD	4	2.1	0.204	0.016	-0.475	0.871
1990	6	2	48044.118420	0.00052	0.00055	TLR	HAD	3	1.9	0.309	0.091	0.280	0.393
1990	6	3	48045.856625	0.04088	0.00020	CER	HAD	9	5.6	0.276	0.161	0.237	0.201
1990	6	16	48058.129674	0.02213	0.00044	CER	HAD	3	2.9	0.503	0.032	0.323	0.743
1990	6	17	48059.140379	0.01989	0.00031	CER	HAD	7	2.5	0.409	0.189	0.140	0.757
1990	7	12	48084.515211	-.06547	0.00043	HAL	HAD	3	2.9	0.999	0.066	-0.414	0.679
1990	7	13	48085.120214	-.01920	0.00028	CER	LK2	5	4.0	0.102	0.071	0.066	0.236
1990	7	13	48085.122345	-.01910	0.00036	CER	TRA	4	3.1	0.326	0.133	-0.304	0.257
1990	7	13	48085.164536	-.01922	0.00012	CER	HAD	10	6.8	0.113	0.110	-0.003	0.158
1990	7	14	48086.170330	-.02103	0.00017	CER	HAD	8	5.0	0.105	0.082	-0.072	0.159
1990	7	15	48087.128030	-.02270	0.00028	CER	HAD	4	3.3	0.090	0.064	0.003	0.384
1990	7	16	48088.191202	-.02418	0.00020	CER	HAD	10	4.0	0.201	0.183	-0.009	0.229
1990	7	17	48089.135053	-.02557	0.00025	CER	HAD	3	1.7	0.172	0.098	0.395	1.086
1990	7	18	48090.120577	-.02670	0.00018	CER	HAD	4	2.4	0.160	0.116	0.041	0.661
1990	7	18	48090.130878	-.02666	0.00022	CER	TRA	3	1.6	0.071	0.055	0.038	0.992
1990	8	9	48112.497156	-.09926	0.00033	HAL	HAD	4	3.6	0.382	0.062	-0.455	0.435
1990	8	10	48113.455211	-.10106	0.00030	HAL	HAD	3	3.2	0.214	0.069	-0.418	0.795
1990	8	12	48115.056175	-.06306	0.00027	CER	HAD	3	3.8	0.132	0.039	0.101	0.470
1990	8	14	48117.125396	-.06682	0.00032	CER	HAD	3	2.8	0.159	0.116	0.196	0.633
1990	9	10	48144.444673	-.15692	0.00032	TLR	HAD	3	3.1	0.199	0.054	0.281	0.430
1990	9	12	48146.480056	-.15981	0.00022	TLR	HAD	4	2.7	0.066	0.035	0.013	0.256
1990	10	10	48174.140747	-.18719	0.00035	CER	HAD	4	5.0	0.194	0.092	-0.220	0.337
1990	10	11	48175.471009	-.21692	0.00017	TLR	HAD	5	2.8	0.102	0.054	0.046	0.340
1990	10	27	48191.842839	-.22671	0.00071	CER	HAD	5	1.5	0.371	0.118	0.644	0.884
1990	11	6	48201.284404	-.25183	0.00013	CER	HAD	5	1.7	0.144	0.141	-0.038	0.627
1990	11	6	48201.308674	-.25195	0.00026	CER	TRA	3	1.5	0.138	0.069	-0.126	0.970
1990	11	7	48202.289864	-.25387	0.00012	CER	HAD	7	3.4	0.119	0.085	0.193	0.414
1990	11	8	48203.302626	-.25601	0.00013	CER	HAD	5	9.4	0.172	0.077	0.052	0.502
1990	11	23	48218.742585	-.29146	0.00056	CER	HAD	6	2.3	0.144	0.074	0.137	0.583
1990	11	27	48222.885112	-.30278	0.00017	CER	HAD	10	4.9	0.264	0.135	0.293	0.286
1990	11	29	48224.976213	-.30855	0.00013	CER	HAD	11	5.0	0.189	0.151	0.189	0.273
1990	12	7	48232.146427	-.32521	0.00018	CER	HAD	7	7.5	0.218	0.165	-0.175	0.265
1990	12	7	48232.175300	-.32536	0.00049	CER	TRA	3	3.0	0.200	0.023	0.210	0.390
1990	12	8	48233.186886	-.32788	0.00021	CER	HAD	7	6.6	0.295	0.205	-0.145	0.221
1990	12	8	48233.199723	-.32794	0.00029	CER	FRM	3	5.2	0.394	0.100	-0.432	0.366
1990	12	8	48233.459679	-.33963	0.00037	TLR	HAD	3	2.6	0.234	0.003	-0.256	0.541

1990	12	9	48234.516466	-.34232	0.00039	TLR	HAD	5	2.3	0.124	0.093	-0.085	0.341
1990	12	22	48247.757964	-.35665	0.00049	CER	HAD	5	1.9	0.154	0.074	0.272	0.849
1990	12	23	48248.755280	-.35890	0.00046	CER	HAD	3	2.4	0.242	0.149	-0.127	0.608
1990	12	23	48248.757402	-.35898	0.00050	CER	FRM	3	2.4	0.182	0.142	0.152	0.674
1990	12	27	48252.815080	-.36881	0.00049	CER	HAD	4	2.4	0.251	0.158	-0.207	0.313
1990	12	28	48253.896801	-.37128	0.00027	CER	HAD	8	3.6	0.213	0.062	0.276	0.233
1990	12	28	48253.925913	-.37114	0.00041	CER	FRM	3	2.8	0.054	0.004	0.009	0.485
1991	1	18	48274.695357	0.58458	0.00052	CER	HAD	4	1.9	0.107	0.095	0.095	1.148
1991	1	20	48276.736956	0.57963	0.00034	CER	HAD	5	3.1	0.205	0.177	0.003	0.656
1991	1	21	48277.688143	0.57697	0.00047	CER	HAD	3	3.3	0.349	0.058	0.394	0.438
1991	1	22	48278.780508	0.57456	0.00012	CER	HAD	11	7.1	0.292	0.091	0.199	0.202
1991	1	22	48278.812851	0.57450	0.00020	CER	FRM	3	3.9	0.196	0.007	-0.199	0.484
1991	1	23	48279.767196	0.57243	0.00010	CER	HAD	14	8.7	0.243	0.155	0.036	0.182
1991	1	23	48279.819450	0.57229	0.00017	CER	FRM	6	5.6	0.171	0.083	-0.072	0.313
1991	1	23	48279.835644	0.57221	0.00022	CER	TRA	5	4.5	0.373	0.065	0.436	0.457
1991	1	24	48280.801890	0.57023	0.00013	CER	HAD	8	9.1	0.139	0.116	-0.126	0.430
1991	1	25	48281.868061	0.56833	0.00012	CER	HAD	13	9.1	0.241	0.196	0.080	0.230
1991	1	25	48281.898274	0.56847	0.00026	CER	FRM	3	5.4	0.259	0.233	-0.248	0.609
1991	1	27	48283.022176	0.56662	0.00019	CER	TRA	3	1.8	0.291	0.181	-0.510	0.957
1991	1	27	48283.024554	0.56647	0.00010	CER	HAD	8	4.4	0.232	0.099	0.203	0.289
1991	1	27	48283.033208	0.56647	0.00016	CER	FRM	4	3.1	0.175	0.048	0.131	0.522
1991	1	27	48283.990411	0.56497	0.00036	CER	FRM	3	7.2	0.074	0.058	0.145	1.118
1991	1	27	48283.990741	0.56480	0.00011	CER	HAD	10	8.6	0.327	0.188	0.196	0.432
1991	2	5	48292.202562	0.54557	0.00040	CER	HAD	5	3.9	0.446	0.202	-0.401	0.311
1991	2	22	48309.130377	0.50758	0.00027	TLR	HAD	3	2.7	0.277	0.091	0.180	0.375
1991	2	22	48309.790811	0.50981	0.00052	CER	HAD	3	3.0	0.115	0.101	0.016	0.454
1991	2	23	48310.896127	0.50762	0.00028	CER	HAD	5	2.5	0.227	0.050	0.036	0.506
1991	2	24	48311.928797	0.50573	0.00009	CER	HAD	21	8.2	0.175	0.168	0.075	0.151
1991	2	24	48311.983070	0.50594	0.00018	CER	FRM	6	2.7	0.401	0.183	-0.236	0.554
1991	2	25	48312.976411	0.50346	0.00009	CER	HAD	18	7.8	0.166	0.127	-0.089	0.165
1991	3	20	48335.732758	0.45331	0.00049	CER	HAD	3	1.8	0.324	0.190	0.641	0.968
1991	3	27	48342.979229	0.43856	0.00020	CER	HAD	7	4.9	0.072	0.070	-0.007	0.298
1991	4	19	48365.823215	0.39121	0.00012	CER	HAD	7	2.8	0.098	0.091	0.060	0.503
1991	4	21	48367.867202	0.38724	0.00019	CER	HAD	8	3.8	0.164	0.102	-0.036	0.421
1991	4	21	48367.888531	0.38733	0.00027	CER	FRM	5	2.4	0.120	0.087	-0.054	0.787
1991	6	4	48411.447729	0.27116	0.00058	TLR	HAD	4	1.6	0.209	0.053	-0.260	0.651
1991	7	3	48440.114438	0.25857	0.00031	CER	HAD	7	3.0	0.233	0.194	-0.017	0.278
1991	8	1	48469.107172	0.22249	0.00026	CER	HAD	7	4.0	0.196	0.175	-0.093	0.256
1991	8	2	48470.170478	0.22098	0.00020	CER	HAD	8	6.8	0.120	0.082	0.089	0.210
1991	8	3	48471.109866	0.21974	0.00016	CER	HAD	11	4.1	0.152	0.121	-0.144	0.300
1991	8	4	48472.048138	0.21876	0.00016	CER	HAD	4	1.7	0.515	0.357	1.068	1.130
1991	10	3	48532.218850	0.10371	0.00017	CER	HAD	7	5.4	0.165	0.144	0.095	0.315
1991	10	4	48533.188008	0.10117	0.00027	CER	HAD	4	2.0	0.180	0.055	-0.353	1.189
1991	10	30	48559.437528	0.00676	0.00027	TLR	HAD	4	2.1	0.227	0.112	0.131	0.682
1991	11	1	48561.211419	0.03785	0.00018	CER	HAD	6	4.3	0.264	0.078	-0.069	0.272
1991	11	25	48585.119529	-.02069	0.00010	CER	HAD	10	8.3	0.272	0.079	0.032	0.216
1991	11	26	48586.187223	-.02345	0.00014	CER	HAD	7	8.7	0.221	0.240	0.013	0.272
1991	11	27	48587.478643	-.05667	0.00019	TLR	HAD	6	3.7	0.174	0.108	0.011	0.229
1991	11	28	48588.134538	-.02910	0.00033	CER	TRA	4	2.8	0.199	0.069	0.267	0.530
1991	11	28	48588.153950	-.02932	0.00012	CER	HAD	10	6.2	0.178	0.095	-0.052	0.193
1991	11	29	48589.198370	-.03273	0.00024	CER	HAD	6	3.5	0.205	0.093	-0.061	0.243
1991	11	30	48590.196032	-.03578	0.00028	CER	HAD	5	3.0	0.109	0.013	-0.213	0.380
1991	12	1	48591.238169	-.03878	0.00022	CER	HAD	9	3.6	0.149	0.084	-0.101	0.270
1991	12	13	48603.719508	-.06915	0.00063	CER	HAD	4	1.5	0.162	0.083	0.147	0.247
1991	12	14	48604.846909	-.07196	0.00027	CER	HAD	5	3.2	0.119	0.108	0.054	0.516
1991	12	14	48604.848439	-.07189	0.00036	CER	FRM	3	2.2	0.135	0.123	-0.096	0.698
1991	12	15	48605.094711	-.09685	0.00054	TLR	HAD	3	2.5	0.911	0.265	0.819	0.615
1991	12	15	48605.805842	-.07471	0.00014	CER	HAD	11	5.3	0.203	0.134	0.184	0.160
1991	12	16	48606.736376	-.07694	0.00034	CER	HAD	4	3.3	0.217	0.125	0.185	0.390
1991	12	17	48607.784719	-.07985	0.00034	CER	HAD	4	2.8	0.171	0.143	0.139	0.322
1991	12	26	48616.197104	-.09968	0.00028	CER	HAD	5	3.2	0.370	0.143	-0.307	0.253
1991	12	28	48618.214299	-.10479	0.00027	CER	HAD	4	4.1	0.361	0.036	-0.276	0.274
1991	12	29	48619.239149	-.10771	0.00029	CER	HAD	7	3.6	0.231	0.076	0.203	0.240
1991	12	30	48620.234282	-.11006	0.00039	CER	HAD	4	2.4	0.319	0.091	0.245	0.382

1992	1	12	48633.808400	-.14134	0.00053	CER	HAD	4	1.6	0.208	0.125	0.093	0.852
1992	1	13	48634.801829	-.14403	0.00012	CER	HAD	12	6.2	0.161	0.149	-0.077	0.164
1992	1	15	48636.907514	-.14928	0.00013	CER	HAD	6	6.6	0.306	0.236	-0.104	0.273
1992	1	16	48637.917730	-.15155	0.00016	CER	HAD	5	5.7	0.177	0.090	-0.131	0.297
1992	2	8	48660.757023	-.21179	0.00036	CER	HAD	3	1.8	0.081	0.048	-0.070	0.929
1992	3	10	48691.784111	-.28843	0.00042	CER	HAD	4	2.3	0.157	0.134	0.214	0.958
1992	3	12	48693.928185	-.29364	0.00013	CER	HAD	4	2.0	0.089	0.070	-0.153	0.736
1992	3	14	48695.937944	-.29868	0.00026	CER	HAD	5	2.9	0.313	0.149	-0.564	0.450
1992	3	16	48697.900906	-.30546	0.00016	CER	HAD	7	5.7	0.406	0.121	-0.390	0.215
1992	4	10	48722.824697	-.37229	0.00043	CER	FRM	3	3.4	0.299	0.046	0.303	0.668
1992	4	10	48722.873044	-.37254	0.00011	CER	HAD	11	6.1	0.146	0.081	0.010	0.233
1992	4	11	48723.842062	-.37519	0.00014	CER	HAD	8	5.3	0.100	0.064	-0.058	0.193
1992	4	12	48724.862619	-.37801	0.00024	CER	FRM	6	5.2	0.535	0.132	0.434	0.237
1992	4	12	48724.884617	-.37819	0.00027	CER	TRA	4	3.8	0.200	0.133	0.020	0.321
1992	4	12	48724.906360	-.37837	0.00013	CER	HAD	10	5.6	0.095	0.079	-0.088	0.205
1992	4	14	48726.929809	-.38563	0.00068	CER	HAD	4	2.2	0.273	0.063	-0.025	0.433
1992	4	22	48734.124958	-.40451	0.00028	CER	HAD	7	3.0	0.069	0.065	0.028	0.200
1992	5	9	48751.859156	-.44453	0.00019	CER	HAD	6	3.2	0.199	0.147	-0.267	0.413
1992	5	10	48752.879815	-.44721	0.00015	CER	HAD	7	4.5	0.103	0.100	0.005	0.280
1992	5	11	48753.144148	-.45921	0.00036	TLR	HAD	4	2.6	0.433	0.141	0.160	0.453
1992	5	12	48754.145225	-.46209	0.00048	TLR	HAD	4	1.9	0.360	0.056	0.255	0.320
1992	5	13	48755.900189	-.45506	0.00017	CER	HAD	8	4.7	0.152	0.117	0.102	0.180
1992	5	14	48756.989125	-.45771	0.00057	CER	HAD	5	1.6	0.226	0.168	0.291	0.619
1992	6	8	48781.859049	-.50409	0.00023	CER	HAD	6	3.1	0.110	0.047	-0.194	0.383
1992	6	21	48794.138611	-.52112	0.00029	CER	HAD	6	3.2	0.239	0.115	0.237	0.217

During all of our efforts under this Grant we continued to build upon that which had already been established. We continued near-real-time earth orientation computations, co-operating with colleagues around the world in support of the International Earth Orientation Service. On-going efforts on this front were those needed to make the system more responsive, more precise, and more effective.

We continued to monitor LAGEOS orbit prediction capabilities (especially that which was being performed at UT/CSR and the Royal Greenwich Observatory, for example) with respect to real-time, on-site Earth orientation parameter computations. We also kept abreast, along with our colleagues at UT/CSR, of the ways in which the two Soviet Etalon targets might be used to produce better Earth orientation products. Along with Mr. Richard J. Eanes we attempted to determine the best time and methods to attempt a joint, all-optical reduction of earth orientation parameters using both artificial satellite and lunar data.

Finally, we continued our examination of combining the LLR observations from the presently active lunar stations (and any others which would come on line from time to time) and investigated a completely independent three-dimensional solution for Earth orientation, if suitable improvements in lunar data volume and density were to become available to warrant such an effort.

Conclusions

We believe that the efforts which we have made toward our original NASA Grant NAG5-754 goals have been substantial and well in keeping with the spirit of the original plans set down in the original proposal. We feel that this effort merited the continuation of funding which they had received through the final months of Crustal Dynamics Project activity, to assure that the final and most ambitious of the goals, i. e., the on-site, joint, real-time production of earth orientation parameters using both lunar and LAGEOS (and Etalon) laser ranging data and the coordinated multi-lunar station results, can be brought to fruition.

Our principal effort during the closing months of this Grant was to continue our LLR-based input into the International Earth Rotation Service (IERS) as we make a transition to other funding sources.

Acknowledgements

We have already mentioned the cooperative effort between this Grant and McDonald Observatory Laser Ranging Operations (NASA Contract NAS5-29404 and the follow-on contract NAS5-30942). In addition we would like to acknowledge Richard J. Eanes, Center for Space Research, University of Texas at Austin , Robert W. King, Department of Earth, Atmosphere, and Planetary Sciences, Massachusetts Institute of Technology and John F. Chandler, Harvard-Smithsonian Center for Astrophysics.

Earth Rotation Parameters from an On-Site Study of Laser Ranging Data

NASA Contract No. NAG5-754

Final Report

Peter J. Shelus, Principal Investigator

1986 March 15 - 1992 June 30

1992 August 25

McDonald Observatory/Department of Astronomy
University of Texas at Austin
Austin, Texas 78712-1083

Introduction

NASA Research Grant NASG 5-754 was originally awarded, through the Crustal Dynamics Project at Goddard Space Flight Center, to the McDonald Observatory, University of Texas at Austin for a one year period beginning 1986 March 15. With a number of supplements and extentions, our efforts continued through 1992 June 30. The scientific results that have been obtained during the more than 6 years of effort on this Grant have been extensive and have been cataloged in the regular semi-annual reports which have been submitted as a routine part of our activities. We believe that we have now brought this Grant to a cost efficient and satisfactory close.

Throughout the entire term of this Grant a multi-faceted effort had been maintained to achieve the following goals:

1. provide for state-of-the-art, on-site, near-real-time Earth orientation parameter determinations at levels of precision and accuracy commensurate with a "quick-look" type of an analysis, using the lunar laser ranging (LLR) data type from the McDonald Laser Ranging Station (MLRS) and other LLR facilities around the world;

2. create a state-of-the-art, highly transportable, LLR-based Earth orientation solution package, which could be easily implemented at LLR facilities other than the MLRS;

3. accommodate, within the routine MLRS lunar range prediction and Earth orientation data analysis software packages, the standard set of Jet Propulsion Laboratory (JPL) Solar System ephemerides, lunar librations, and Solar System partial derivatives;

4. examine, wherever possible, opportunities for the performance of state-of-the-art, on-site, joint, simultaneous, quick-look analysis for Earth orientation parameters, using both MLRS lunar and LAGEOS (and, perhaps, Etalon) ranging observations, as well as from multiple LLR station observations.

Excellent results had been obtained at all levels of effort and it can be said that all of these goals had been attained. The reader is referred to the complete series of our semi-annual reports for a full description of our evolving efforts under this Grant.

On-Site, Near-Real-Time UT-0 Determinations

As we have already mentioned above, the first goal of this Grant has been fully realized. An on-site, state-of-the-art, near-real-time Earth orientation analysis software system is in place and in routine operation at the MLRS (located at McDonald Observatory in far west Texas) and at the Department of Astronomy at the University of Texas at Austin. The relevant Earth orientation parameters (i.e., ΔUT0 and $\Delta\phi$) are routinely being supplied, on a weekly basis, in a quick-look, turn-around mode to the International Earth Rotation Service (IERS) at the Observatoire de Paris in Paris, France, the U. S. Naval Observatory (USNO) in Washington, DC, the Jet Propulsion Laboratory (JPL) in Pasadena, CA, and the Centre d'Etudes et de Recherches Geodynamiques et Astronomiques (CERGA) in Grasse, France via Internet E-mail. Also,

under this Grant, we were participating fully as an Observational Center as well as an Analysis Center for Lunar Laser Ranging within the International Earth Orientation Service (IERS).

A Transportable LLR Earth Orientation Analysis Package

The second goal of this Grant has also been realized. Highly transportable versions of our state-of-the-art, quick-look-data-based MLRS Earth orientation data analysis software package have been supplied by us to lunar laser ranging operations at the University of Hawaii/Institute for Astronomy LURE Observatory atop Mt. Haleakala on the island of Maui and to the Orroral Observatory laser ranging station in Orroral Valley, Australia. In addition, moderate efforts continued to be expended on moving the lunar prediction, filtering, normal pointing, and certain Earth orientation related software to CDP/Hewlett-Packard workstations computers, installed here in Austin as well as at the MLRS. This project was an unmitigated success. And, the process of "porting" this software to the new H-P computing environment has enhanced its portability significantly. All of this software can be moved to the LURE/H-P workstation at the LURE Observatory on Mt. Haleakala on the island of Maui, as well as to the one at Orroral Observatory in Australia, when suitable workstations become available at those sites.

Use of General JPL Solar System Ephemerides, Lunar Rotation Data Bases, and Solar System Partial Derivative Data Products

With respect to the third proposed goal of this Grant, the current level of agreement between the JPL results and our own indicates that our implementation of the JPL solar system ephemeris, lunar libration, and partial derivative material is more than adequate for predictive purposes. Further, efforts using the MIT-based Planetary Ephemeris Program (PEP) system, has shown us that the JPL material is an important "back-up" (for us) to PEP. The latest JPL ephemeris has also being implemented on the H-P workstation mentioned above. Therefore, we state that Proposed Goal # 3 has also been attained.

Lunar/LAGEOS and Multi-Station Earth Rotation Data Products

Goal # 4 has also been attained. At the close of our operations under this Grant, the LLR network is still not able to provide lunar data in a volume and density sufficient to determine, in and of itself, all three components of Earth orientation. As a part of the effort which had been expended under this contract, however, in using a UT/CSR LAGEOS polar motion data product, we were able to provide single station UT0 and variation of latitude estimations of the first quality for lunar data being gathered at the Maui, CERGA, McDonald, and other sites. Figure 1 illustrates the volume and density of this LLR Earth orientation data product, on a quarterly basis, throughout the duration of this Grant. Figure 2 attests to the quality of this data product through a long-term UT2R-TAI comparison with VLBI. The following summarizes the manner and the rationale under which this information has been extracted from the LLR data under this Grant.

The extraction of "quick-look" Earth orientation parameters from any set of laser ranging data requires the best possible (O-C) residuals. This requires that an excellent set of a priori Earth orientation series must be available. As stated above, we have used, as our present a

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Figure 1: Lunar Network Statistics

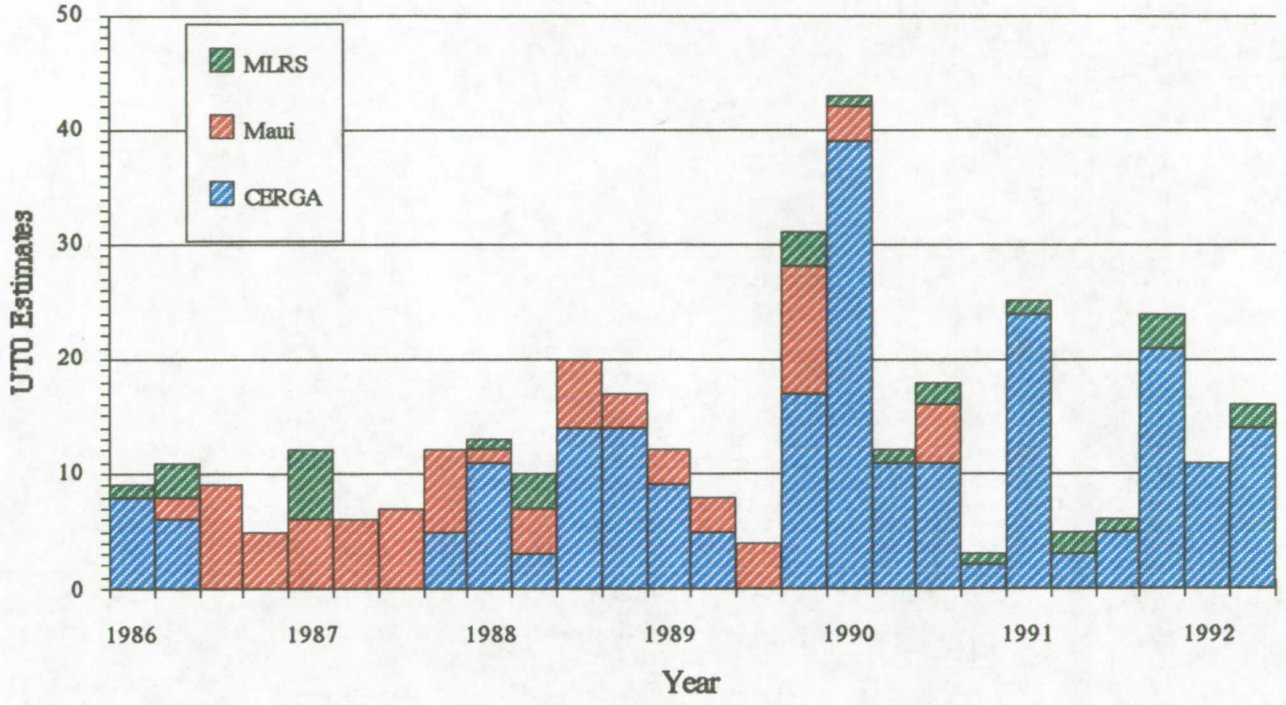
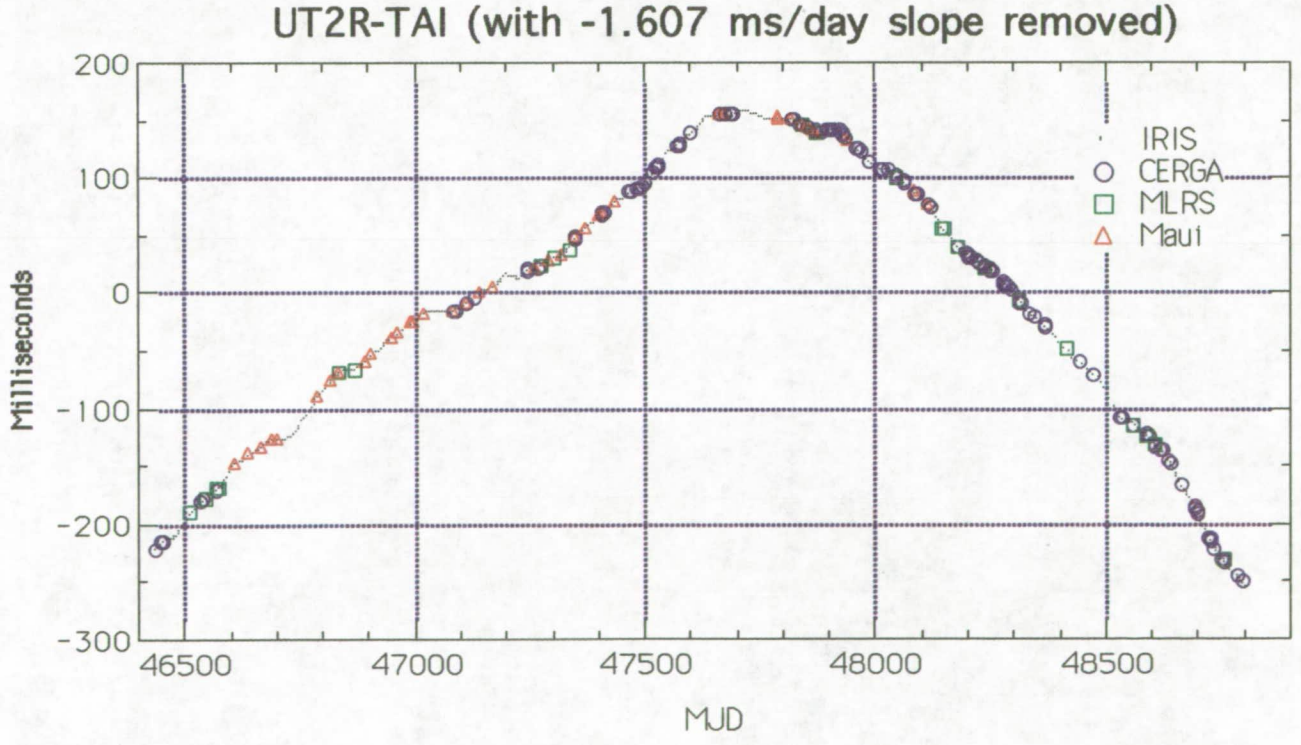


Figure 2



priori's, a set of Earth orientation series which were produced by the University of Texas Center for Space Research (UT/CSR). These UT/CSR LAGEOS reductions are capable of a completely independent determination of polar motion at the millisecond of arc level. They are also capable of the determination of short-period variations in Universal Time (UT) at the few tenths of a millisecond of time level. UT/CSR maintains a set of continuous and smoothed Earth orientation series back to 1976, and which are updated weekly. The only deficiency in these series is the stochastic, long-term drift in the node of the LAGEOS orbit. This drift is highly correlated with UT and causes a non-linear runoff in the UT/CSR UT series (which can be as large as 1 millisecond of time per month). This runoff has been controlled by UT/CSR's tying their UT series to the IRIS/VLBI UT series. This works well, except for the fact that the IRIS series are almost always more than a month old at the tie point.

The Universal Time computations, which were performed as a cooperative effort between this Crustal Dynamics Project Grant and NASA Contract NAS5-30942 (formerly NASA Contract NAS5-29404), were as follows. The station by station lunar data were first edited and re-weighted using an automated and objective scheme which identified suspected outliers. A follow-on procedure adjusted each observing station's assigned weight in an attempt to yield consistent distributions of the weighted residuals for all stations. The Massachusetts Institute of Technology (MIT) Planetary Ephemeris Program (PEP) was then used to estimate corrections to global parameters. In the main, MERIT standards were being used with constrained corrections to the constant of precession, obliquity of the ecliptic, and the 18.6 year, annual, semi-annual, and fortnightly nutation terms. Adjustments were made for the Earth-Moon barycenter orbit, the lunar orbit, and the lunar librations. We estimated third degree and order lunar gravitational potentials, the lunar love number, the lunar dissipation parameter, and the selenocentric retroreflector coordinates. Also estimated were piecewise linear splines to all three components of Earth orientation. Lastly, time delay biases, relative to MLRS, for CERGA and Maui were estimated. The node of the Earth-Moon barycenter orbit was fixed to tie the longitude of the celestial frame. The longitude of the terrestrial frame was tied by fixing the zero point of the CSR Earth orientation adjustments. The AM0-2 plate motion model was used without adjustment. As mentioned earlier, our a priori Earth orientation series came from UT/CSR.

Following the global solution, post-fit residuals were then analyzed in the usual fashion (e.g., Stolz et al.[1]) to determine daily corrections to Earth orientation. Such Earth orientation parameters from single station lunar laser ranging (LLR) data were derived by estimating the variation of latitude, $\Delta\phi$, and the change in UT0, ΔUT0. A minimum of three normal points for each station/reflector pair and at least 1.5 hours of lunar hour angle coverage was the criteria which had been routinely adopted for our daily UT estimations (although a very few exceptions to these criteria had been made in cases where it was deemed necessary). These estimates were provided to the IERS Rapid Service Sub-Bureau at the U. S. Naval Observatory in Washington, DC and to the Central Bureau of the IERS at the Observatoire de Paris in Paris, France

[1]Stolz, A. P., P. L. Bender, J. E. Faller, E. C. Silverberg, J. D. Mulholland, P. J. Shelus, J. G. Williams, W. E. Carter, D. G. Currie, W. M. Kaula, "Earth Rotation Measured by Lunar Laser Ranging", *Science*, **193**, 997-999, 1976.

as they became available (working to a weekly schedule). Copies of these results also went to the Jet Propulsion Laboratory in Pasadena, CA and to the Centre d'Etudes et de Recherches Geodynamiques et Astronomiques in Grasse, France. It is important to note that in the production of our Earth orientation products, we were able to see the UT/CSR UT runoff when using the LLR residuals. We provided this information to UT/CSR which should eventually allow them to apply a correction to their series in a time frame shorter than they can do with IRIS/VLBI results. In Table 1 we present those UT0-UTC estimates which were made in Austin during the course of the Grant.

Table 1.

MINIMUM NUMBER OF POINTS = 3, MINIMUM HOUR ANGLE COVERAGE = 1.5

YR	MO	DA	MJD	UT0-UTC (SEC)	S.D. (SEC)	STA	REF	NUM	DHA	PRE WRMS (NS)	POST WRMS (NS)	BIAS (NS)	S.D. (NS)
1986	1	4	46434.192789	0.31934	0.00034	CER	HAD	9	4.9	0.583	0.484	0.060	0.422
1986	1	16	46446.778641	0.30057	0.00031	CER	HAD	8	5.2	0.576	0.499	0.387	0.539
1986	1	17	46447.780844	0.29860	0.00040	CER	HAD	5	4.6	0.433	0.273	0.394	0.541
1986	1	17	46447.823633	0.29844	0.00038	CER	LK2	4	4.8	0.765	0.154	-0.514	0.735
1986	1	18	46448.887177	0.29675	0.00035	CER	HAD	7	2.8	0.408	0.327	0.573	0.953
1986	1	19	46449.877024	0.29609	0.00073	CER	HAD	3	2.4	1.306	0.916	0.471	1.257
1986	1	20	46450.839566	0.29389	0.00022	CER	HAD	9	10.3	0.701	0.453	0.160	0.484
1986	1	20	46450.920001	0.29477	0.00031	CER	FRM	5	6.5	1.023	0.484	0.529	0.576
1986	3	23	46512.113507	0.20030	0.00021	MLR	HAD	3	4.8	0.135	0.120	-0.117	0.459
1986	4	13	46533.826543	0.17382	0.00051	CER	HAD	5	1.5	0.379	0.194	-0.157	1.677
1986	4	18	46538.841449	0.16821	0.00020	CER	HAD	12	8.7	0.562	0.527	-0.161	0.526
1986	4	19	46539.873982	0.16655	0.00026	CER	HAD	10	6.6	0.821	0.750	0.399	0.420
1986	4	22	46542.237729	0.15274	0.00020	MLR	HAD	3	5.9	0.256	0.079	0.051	0.350
1986	5	16	46566.844916	0.12665	0.00073	CER	HAD	4	1.9	0.702	0.598	-1.140	1.455
1986	5	17	46567.798537	0.12549	0.00094	CER	HAD	4	2.3	0.589	0.510	-0.417	0.618
1986	5	18	46568.839932	0.12350	0.00033	CER	HAD	7	5.0	0.319	0.298	0.148	0.438
1986	5	20	46570.147594	0.10877	0.00025	MLR	HAD	3	4.6	0.128	0.080	0.125	0.322
1986	5	21	46571.200918	0.10672	0.00020	MLR	HAD	3	4.8	0.255	0.122	0.253	0.303
1986	6	28	46609.600098	0.06639	0.00052	HAL	HAD	5	1.9	0.351	0.217	-0.691	0.805
1986	6	29	46610.596039	0.06554	0.00041	HAL	HAD	6	2.1	0.258	0.114	0.049	0.991
1986	7	28	46639.579245	0.04468	0.00015	HAL	HAD	8	3.8	0.286	0.200	-0.154	0.400
1986	8	24	46666.469158	0.02526	0.00015	HAL	HAD	5	3.8	0.376	0.292	-0.304	0.539
1986	9	15	46688.403648	0.00663	0.00029	HAL	HAD	7	3.7	0.417	0.269	0.246	0.411
1986	9	25	46698.535831	-.00850	0.00045	HAL	HAD	4	4.9	0.663	0.405	-0.498	0.425
1986	12	23	46787.596904	-.13470	0.00059	HAL	HAD	3	2.1	0.504	0.371	0.314	0.919
1987	1	21	46816.629494	-.17184	0.00023	HAL	HAD	6	5.8	0.343	0.329	-0.040	0.326
1987	1	22	46817.628338	-.17382	0.00047	HAL	HAD	3	3.5	0.511	0.110	-0.662	0.567
1987	2	8	46834.122199	-.19585	0.00030	MLR	HAD	3	3.6	0.190	0.102	-0.254	0.445
1987	2	8	46834.381263	-.19642	0.00231	HAL	HAD	4	2.9	0.188	0.024	0.313	2.172
1987	2	10	46836.474111	-.19834	0.00453	HAL	HAD	3	2.1	0.204	0.007	0.391	4.460
1987	3	12	46866.240691	-.24801	0.00021	MLR	HAD	3	4.7	0.113	0.095	0.043	0.384
1987	3	13	46867.143801	-.24935	0.00024	MLR	HAD	3	2.6	0.146	0.061	0.070	0.522
1987	4	8	46893.336909	-.29417	0.00058	HAL	HAD	6	5.1	0.295	0.253	0.071	0.222
1987	4	20	46905.625205	-.31374	0.00083	HAL	HAD	3	1.8	0.424	0.219	0.782	0.921
1987	6	6	46952.361126	-.37959	0.00033	HAL	HAD	5	2.5	0.195	0.109	0.364	0.904
1987	6	17	46963.581179	-.39228	0.00031	HAL	HAD	6	3.2	0.388	0.158	-0.021	0.522
1987	7	16	46992.589920	-.41390	0.00021	HAL	HAD	5	3.6	0.312	0.194	0.168	0.276
1987	7	17	46993.666303	-.41534	0.00012	HAL	HAD	9	5.7	0.272	0.220	0.127	0.200
1987	8	13	47020.455314	-.43029	0.00016	HAL	HAD	3	2.5	0.114	0.086	-0.153	0.572
1987	8	14	47021.603567	-.43148	0.00008	HAL	HAD	9	7.2	0.084	0.060	0.075	0.218
1987	10	12	47080.577835	-.50860	0.00031	HAL	HAD	6	4.0	0.241	0.102	-0.160	0.267
1987	10	13	47081.071724	-.48356	0.00022	CER	LK2	8	4.1	0.414	0.277	-0.102	0.397
1987	10	14	47082.122120	-.48459	0.00036	CER	LK2	3	4.8	0.347	0.113	-0.031	0.468
1987	10	18	47086.186635	-.49022	0.00023	CER	HAD	6	2.2	0.452	0.265	0.804	0.913

1987	11	10	47109.466109	-.55680	0.00111	HAL	HAD	4	3.3	0.222	0.068	-0.427	1.091
1987	11	11	47110.505918	-.55771	0.00163	HAL	HAD	5	3.6	0.088	0.033	0.140	1.280
1987	11	12	47111.542962	-.55961	0.00074	HAL	HAD	4	2.3	0.023	0.002	-0.024	0.278
1987	11	15	47114.182093	-.53524	0.00044	CER	HAD	6	2.8	0.182	0.096	-0.330	0.780
1987	11	28	47127.845290	-.55725	0.00042	CER	FRM	8	3.8	0.585	0.231	-1.047	0.598
1987	12	11	47140.579751	-.60895	0.00016	HAL	HAD	5	5.0	0.103	0.040	-0.107	0.315
1988	1	9	47169.598492	0.34334	0.00037	HAL	HAD	4	2.8	0.101	0.097	-0.013	0.345
1988	3	22	47242.782278	0.25880	0.00014	CER	HAD	6	2.3	0.096	0.049	0.113	0.509
1988	3	23	47243.685924	0.25790	0.00026	CER	HAD	10	4.8	0.193	0.155	0.109	0.186
1988	3	23	47243.713140	0.25789	0.00061	CER	FRM	3	2.3	0.172	0.087	-0.049	0.471
1988	3	24	47244.834809	0.25633	0.00024	CER	FRM	3	2.3	0.111	0.036	0.053	0.651
1988	3	24	47244.842061	0.25635	0.00016	CER	HAD	4	3.5	0.135	0.059	0.021	0.373
1988	3	26	47246.833691	0.25400	0.00027	CER	FRM	4	5.4	0.286	0.103	0.134	0.383
1988	3	26	47246.840462	0.25382	0.00016	CER	HAD	7	5.5	0.138	0.103	0.022	0.219
1988	3	26	47246.864432	0.25390	0.00029	CER	TRA	3	4.2	0.257	0.157	-0.050	0.428
1988	3	27	47247.844219	0.25242	0.00021	CER	TRA	7	5.3	0.107	0.087	0.079	0.267
1988	3	27	47247.847305	0.25238	0.00018	CER	HAD	10	5.4	0.230	0.154	0.213	0.191
1988	3	27	47247.865807	0.25243	0.00028	CER	FRM	5	4.2	0.293	0.287	0.030	0.327
1988	4	8	47259.646369	0.19264	0.00037	HAL	HAD	5	3.6	0.323	0.144	0.161	0.334
1988	4	14	47265.389383	0.21611	0.00056	CER	HAD	5	3.2	0.439	0.371	-0.252	0.417
1988	4	22	47273.824461	0.20015	0.00025	CER	HAD	5	2.8	0.640	0.150	-0.495	0.574
1988	4	22	47273.848531	0.20015	0.00025	CER	FRM	3	1.9	0.554	0.082	-0.410	0.996
1988	4	24	47275.135911	0.16441	0.00030	TLR	HAD	3	2.1	0.488	0.025	-0.004	0.590
1988	5	8	47289.634372	0.14152	0.00042	HAL	HAD	5	2.5	0.235	0.091	0.094	0.469
1988	5	24	47305.118817	0.11629	0.00032	TLR	HAD	3	2.5	0.317	0.126	-0.020	0.516
1988	6	5	47317.633414	0.10054	0.00049	HAL	HAD	3	2.1	0.232	0.027	-0.230	0.302
1988	6	6	47318.600762	0.09895	0.00019	HAL	HAD	7	4.2	0.210	0.077	-0.267	0.330
1988	6	23	47335.085606	0.08345	0.00046	TLR	HAD	3	2.7	0.355	0.160	-0.036	0.431
1988	7	5	47347.199529	0.10393	0.00065	CER	HAD	3	1.9	0.191	0.046	-0.199	0.326
1988	7	6	47348.161535	0.10277	0.00023	CER	HAD	6	3.6	0.221	0.126	-0.186	0.240
1988	7	6	47348.607974	0.07879	0.00048	HAL	HAD	4	1.7	0.171	0.099	-0.181	0.849
1988	7	7	47349.128158	0.10165	0.00015	CER	HAD	6	4.5	0.201	0.050	-0.102	0.363
1988	7	7	47349.140743	0.10204	0.00029	CER	TRA	3	3.5	0.596	0.171	-0.359	0.542
1988	7	7	47349.147020	0.10185	0.00042	CER	FRM	3	2.4	0.238	0.095	-0.183	0.683
1988	7	31	47373.571772	0.06810	0.00048	HAL	HAD	3	2.0	0.390	0.042	-0.241	0.493
1988	8	1	47374.553046	0.06694	0.00026	HAL	HAD	3	4.1	0.272	0.070	-0.264	0.336
1988	8	30	47403.483365	0.04967	0.00027	HAL	HAD	3	3.2	0.591	0.062	0.146	0.536
1988	9	1	47405.187848	0.06215	0.00035	CER	HAD	5	2.7	0.209	0.056	0.302	0.252
1988	9	1	47405.193084	0.06201	0.00071	CER	TRA	3	1.7	0.162	0.028	0.110	0.490
1988	9	2	47406.345404	0.06159	0.00011	CER	HAD	7	2.2	0.105	0.053	0.210	0.547
1988	9	2	47406.610101	0.04777	0.00045	HAL	HAD	3	3.6	0.339	0.096	-0.140	0.371
1988	9	4	47408.118904	0.06086	0.00012	CER	HAD	8	6.0	0.189	0.171	0.113	0.216
1988	9	5	47409.132914	0.06060	0.00012	CER	HAD	7	4.5	0.216	0.083	0.148	0.260
1988	9	5	47409.140439	0.06068	0.00016	CER	FRM	4	3.2	0.262	0.056	0.054	0.458
1988	9	5	47409.143360	0.06063	0.00021	CER	LK2	3	2.1	0.197	0.090	0.057	0.841
1988	9	5	47409.154821	0.06054	0.00018	CER	TRA	4	3.1	0.100	0.062	0.127	0.536
1988	9	7	47411.181678	0.05953	0.00014	CER	HAD	4	1.7	0.191	0.165	-0.003	0.875
1988	10	2	47436.572529	0.01891	0.00096	HAL	HAD	5	4.2	0.223	0.133	0.052	0.884
1988	11	2	47467.287519	-.01567	0.00021	CER	HAD	4	4.2	0.175	0.064	0.183	0.294
1988	11	5	47470.220269	-.02081	0.00037	CER	HAD	6	2.0	0.107	0.089	0.055	0.816
1988	11	16	47481.777035	-.03809	0.00026	CER	HAD	5	3.8	0.351	0.216	0.205	0.316
1988	11	20	47485.994526	-.04745	0.00028	CER	HAD	6	2.2	0.180	0.099	0.234	0.653
1988	11	29	47494.286825	-.05831	0.00031	CER	HAD	7	2.5	0.315	0.130	-0.266	0.647
1988	12	3	47498.194804	-.06523	0.00041	CER	HAD	5	3.0	0.128	0.081	0.028	0.631
1988	12	20	47515.894315	-.08777	0.00008	CER	HAD	21	9.3	0.289	0.180	0.124	0.170
1988	12	20	47515.943620	-.08753	0.00025	CER	FRM	3	6.3	0.211	0.049	0.261	0.594
1988	12	29	47524.266025	-.09378	0.00021	CER	HAD	8	3.1	0.071	0.038	-0.111	0.336
1988	12	30	47525.260732	-.09514	0.00018	CER	HAD	11	4.4	0.157	0.152	-0.073	0.212
1988	12	31	47526.217145	-.09663	0.00051	CER	LK2	4	2.7	0.102	0.042	-0.028	0.319
1988	12	31	47526.218365	-.09647	0.00012	CER	HAD	13	6.6	0.129	0.076	-0.108	0.161
1988	12	31	47526.222661	-.09663	0.00024	CER	TRA	6	5.6	0.525	0.115	-0.559	0.253
1988	12	31	47526.252600	-.09657	0.00036	CER	FRM	4	3.7	0.370	0.069	-0.377	0.319
1989	1	1	47527.199356	-.09775	0.00027	CER	HAD	5	3.9	0.145	0.090	-0.102	0.298
1989	1	1	47527.243613	-.09786	0.00048	CER	FRM	3	3.2	0.536	0.011	-0.564	0.370

1989	2	9	47566.769503	-.14461	0.00040	CER	HAD	6	1.5	0.235	0.111	-0.265 1.538
1989	2	11	47568.836609	-.14860	0.00023	CER	HAD	4	2.9	0.233	0.040	-0.264 0.863
1989	2	14	47571.867011	-.15179	0.00067	CER	HAD	4	1.7	0.485	0.038	-0.610 0.767
1989	2	16	47573.880274	-.15308	0.00012	CER	HAD	13	8.3	0.258	0.214	-0.125 0.230
1989	3	11	47596.797274	-.18565	0.00014	CER	HAD	4	3.3	0.159	0.096	-0.114 0.548
1989	3	12	47597.828183	-.18729	0.00016	CER	HAD	5	2.7	0.099	0.097	-0.071 0.766
1989	3	13	47598.782547	-.18855	0.00035	CER	HAD	7	3.1	0.088	0.074	0.050 0.437
1989	5	13	47659.316935	-.33044	0.00017	HAL	HAD	6	3.5	0.315	0.067	0.340 0.479
1989	5	13	47659.870095	-.28933	0.00022	CER	HAD	9	3.8	0.184	0.129	0.322 0.383
1989	5	15	47661.873931	-.29326	0.00029	CER	HAD	8	3.9	0.223	0.077	0.248 0.306
1989	5	16	47662.293765	-.33607	0.00050	HAL	HAD	4	2.2	0.288	0.103	0.275 0.312
1989	5	27	47673.561171	-.35312	0.00066	HAL	HAD	5	1.6	0.300	0.102	-0.340 1.399
1989	5	28	47674.254065	-.31363	0.00032	CER	HAD	7	3.1	0.150	0.137	0.017 0.221
1989	6	8	47685.835568	-.33249	0.00022	CER	HAD	5	1.7	0.563	0.108	-0.156 1.408
1989	6	11	47688.877842	-.33774	0.00044	CER	HAD	5	2.3	0.198	0.107	0.008 1.041
1989	9	19	47788.486323	-.47834	0.00027	HAL	HAD	12	5.6	0.085	0.084	0.010 0.158
1989	9	20	47789.553080	-.47952	0.00036	HAL	HAD	9	3.6	0.148	0.081	-0.062 0.312
1989	9	21	47790.510220	-.48051	0.00237	HAL	HAD	7	2.4	0.112	0.047	-0.088 2.341
1989	10	18	47817.190120	-.51450	0.00009	CER	HAD	17	7.3	0.147	0.130	0.063 0.174
1989	10	18	47817.544428	-.52383	0.00033	HAL	HAD	4	3.1	0.136	0.088	0.052 0.251
1989	10	19	47818.183692	-.51612	0.00029	CER	HAD	9	3.1	0.133	0.093	-0.086 0.237
1989	10	19	47818.574045	-.52562	0.00034	HAL	HAD	5	3.8	0.152	0.062	0.111 0.289
1989	10	20	47819.200346	-.51815	0.00013	CER	HAD	13	5.6	0.249	0.158	-0.230 0.165
1989	10	21	47820.597128	-.52941	0.00104	HAL	HAD	6	2.7	0.228	0.064	-0.051 0.503
1989	10	22	47821.154816	-.52205	0.00044	CER	LK2	3	2.7	0.082	0.041	-0.142 0.777
1989	10	22	47821.211020	-.52200	0.00020	CER	TRA	4	6.7	0.222	0.130	0.279 0.346
1989	10	22	47821.231556	-.52215	0.00009	CER	HAD	14	8.5	0.149	0.145	-0.002 0.158
1989	10	22	47821.311253	-.52221	0.00028	CER	FRM	6	4.3	0.163	0.137	-0.004 0.324
1989	11	7	47837.771553	-.55696	0.00077	CER	HAD	3	1.7	0.069	0.037	-0.041 0.289
1989	11	8	47838.336168	-.56489	0.00066	HAL	HAD	4	1.6	0.184	0.062	0.226 1.213
1989	11	8	47838.808888	-.55962	0.00059	CER	HAD	5	2.2	0.181	0.087	-0.155 0.245
1989	11	9	47839.148412	-.56658	0.00038	TLR	HAD	3	3.8	0.424	0.203	-0.459 0.413
1989	11	9	47839.371552	-.56743	0.00055	HAL	HAD	3	1.9	0.256	0.038	-0.173 1.068
1989	11	10	47840.170868	-.56952	0.00027	TLR	HAD	3	4.7	0.326	0.051	-0.284 0.396
1989	11	11	47841.005471	-.56586	0.00014	CER	HAD	9	4.0	0.204	0.151	0.017 0.337
1989	11	20	47850.603742	-.59190	0.00030	HAL	HAD	3	3.1	0.278	0.155	0.388 0.638
1989	11	23	47853.238809	-.59221	0.00028	CER	HAD	5	3.2	0.185	0.055	-0.072 0.391
1989	11	23	47853.256090	-.59223	0.00055	CER	TRA	3	2.5	0.321	0.056	0.179 0.572
1989	12	6	47866.320020	-.62583	0.00029	HAL	HAD	4	3.1	1.116	0.057	0.183 0.799
1989	12	7	47867.746133	-.62204	0.00030	CER	HAD	5	3.1	0.393	0.052	-0.041 0.241
1989	12	8	47868.354017	-.63126	0.00024	HAL	HAD	5	2.3	0.372	0.165	-0.178 0.623
1989	12	8	47868.850139	-.62462	0.00017	CER	HAD	7	4.7	0.383	0.098	-0.181 0.193
1989	12	8	47868.888157	-.62488	0.00027	CER	FRM	4	4.2	0.277	0.113	-0.302 0.351
1989	12	9	47869.216362	-.63019	0.00020	TLR	HAD	3	5.0	0.690	0.248	-0.597 0.444
1989	12	9	47869.823668	-.62696	0.00018	CER	HAD	8	4.9	0.113	0.045	-0.010 0.170
1989	12	20	47880.222834	-.64461	0.00035	CER	HAD	4	3.6	0.198	0.039	-0.198 0.245
1990	1	3	47894.812931	0.33233	0.00020	CER	HAD	5	4.7	0.290	0.138	-0.467 0.391
1990	1	4	47895.798312	0.33015	0.00013	CER	HAD	14	6.4	0.078	0.077	-0.009 0.171
1990	1	4	47895.831997	0.33005	0.00038	CER	FRM	3	3.2	0.069	0.044	-0.031 0.714
1990	1	5	47896.741037	0.32843	0.00014	CER	HAD	10	6.8	0.145	0.055	0.022 0.198
1990	1	5	47896.767998	0.32867	0.00045	CER	TRA	3	2.9	0.366	0.067	-0.256 0.317
1990	1	7	47898.926150	0.32495	0.00009	CER	HAD	21	9.0	0.220	0.171	0.168 0.169
1990	1	14	47905.007266	0.31707	0.00051	CER	TRA	3	2.3	0.230	0.001	-0.401 0.689
1990	1	14	47905.048678	0.31734	0.00008	CER	HAD	20	8.8	0.311	0.134	-0.069 0.146
1990	1	15	47906.128386	0.31542	0.00013	CER	HAD	8	7.6	0.205	0.139	-0.039 0.274
1990	1	16	47907.124750	0.31361	0.00009	CER	HAD	12	8.2	0.142	0.137	-0.032 0.160
1990	1	16	47907.173211	0.31361	0.00023	CER	FRM	4	5.5	0.161	0.118	-0.079 0.301
1990	1	16	47907.176965	0.31346	0.00019	CER	TRA	6	6.6	0.306	0.119	0.364 0.288
1990	1	17	47908.191003	0.31175	0.00017	CER	HAD	8	6.1	0.108	0.106	-0.019 0.209
1990	1	18	47909.153580	0.31023	0.00023	CER	HAD	6	4.2	0.081	0.076	-0.004 0.249
1990	1	18	47909.161614	0.31023	0.00032	CER	TRA	4	3.8	0.192	0.096	0.214 0.292
1990	1	19	47910.225664	0.30850	0.00028	CER	HAD	8	4.0	0.146	0.102	-0.094 0.186
1990	1	30	47921.748621	0.29082	0.00025	CER	HAD	7	3.0	0.232	0.126	-0.663 0.590
1990	1	30	47921.759060	0.29080	0.00037	CER	LK2	4	2.4	0.433	0.122	-0.022 1.142

1990	2	2	47924.824082	0.28302	0.00019	CER	HAD	5	5.8	0.168	0.082	-0.027	0.331
1990	2	3	47925.915065	0.28085	0.00012	CER	HAD	7	2.9	0.227	0.067	0.354	0.454
1990	2	4	47926.890102	0.27911	0.00013	CER	TRA	9	6.3	0.182	0.155	0.040	0.231
1990	2	4	47926.911648	0.27902	0.00009	CER	HAD	11	7.8	0.217	0.086	0.078	0.161
1990	2	4	47926.931536	0.27917	0.00011	CER	FRM	9	7.1	0.208	0.089	0.312	0.250
1990	2	5	47927.928705	0.27736	0.00010	CER	HAD	12	9.7	0.169	0.158	0.079	0.216
1990	2	5	47927.976423	0.27740	0.00014	CER	FRM	6	8.1	0.388	0.326	0.282	0.429
1990	2	6	47928.021518	0.27721	0.00019	CER	TRA	3	1.6	0.274	0.274	-0.049	0.989
1990	2	7	47929.006995	0.27535	0.00016	CER	HAD	5	4.5	0.229	0.127	-0.124	0.345
1990	2	9	47931.848227	0.26925	0.00031	CER	HAD	7	1.7	0.117	0.033	-0.672	1.147
1990	2	14	47936.613089	0.23535	0.00029	HAL	HAD	4	3.9	0.579	0.171	-0.483	0.354
1990	3	5	47955.793170	0.22183	0.00011	CER	HAD	9	10.9	0.403	0.346	-0.320	0.272
1990	3	6	47956.876746	0.22005	0.00015	CER	HAD	8	7.0	0.131	0.078	-0.054	0.213
1990	3	6	47956.878514	0.21991	0.00034	CER	TRA	3	3.4	0.205	0.064	0.203	0.383
1990	3	6	47956.955578	0.22031	0.00021	CER	FRM	4	3.8	0.433	0.116	-0.001	0.497
1990	3	7	47957.826087	0.21822	0.00049	CER	TRA	3	2.6	0.410	0.099	0.306	0.445
1990	3	7	47957.834920	0.21844	0.00013	CER	HAD	9	9.4	0.336	0.337	0.036	0.237
1990	3	9	47959.847151	0.21423	0.00026	CER	HAD	4	3.6	0.176	0.043	-0.243	0.446
1990	3	16	47966.121938	0.20051	0.00041	CER	HAD	5	3.6	0.623	0.184	0.636	0.260
1990	4	1	47982.848200	0.16338	0.00012	CER	HAD	6	3.3	0.241	0.066	-0.143	0.350
1990	4	1	47982.905098	0.16309	0.00026	CER	FRM	3	3.1	0.747	0.138	0.346	0.679
1990	4	28	48009.823830	0.10710	0.00027	CER	HAD	3	5.0	0.375	0.032	0.221	0.448
1990	4	30	48011.877726	0.10417	0.00015	CER	HAD	4	3.5	0.489	0.105	-0.404	0.527
1990	5	3	48014.883328	0.09879	0.00031	CER	HAD	5	3.8	0.742	0.112	-1.105	0.442
1990	5	4	48015.913937	0.09638	0.00031	CER	HAD	4	3.1	0.584	0.086	-0.490	0.428
1990	5	5	48016.905290	0.09440	0.00028	CER	HAD	5	4.7	0.190	0.079	0.061	0.338
1990	5	18	48029.161878	0.07476	0.00045	CER	HAD	6	2.2	0.282	0.093	0.440	0.678
1990	5	30	48041.843419	0.04926	0.00036	CER	HAD	4	2.0	0.337	0.061	-0.858	0.844
1990	5	31	48042.842267	0.04715	0.00055	CER	HAD	4	2.1	0.204	0.016	-0.475	0.871
1990	6	2	48044.118420	0.00052	0.00055	TLR	HAD	3	1.9	0.309	0.091	0.280	0.393
1990	6	3	48045.856625	0.04088	0.00020	CER	HAD	9	5.6	0.276	0.161	0.237	0.201
1990	6	16	48058.129674	0.02213	0.00044	CER	HAD	3	2.9	0.503	0.032	0.323	0.743
1990	6	17	48059.140379	0.01989	0.00031	CER	HAD	7	2.5	0.409	0.189	0.140	0.757
1990	7	12	48084.515211	-.06547	0.00043	HAL	HAD	3	2.9	0.999	0.066	-0.414	0.679
1990	7	13	48085.120214	-.01920	0.00028	CER	LK2	5	4.0	0.102	0.071	0.066	0.236
1990	7	13	48085.122345	-.01910	0.00036	CER	TRA	4	3.1	0.326	0.133	-0.304	0.257
1990	7	13	48085.164536	-.01922	0.00012	CER	HAD	10	6.8	0.113	0.110	-0.003	0.158
1990	7	14	48086.170330	-.02103	0.00017	CER	HAD	8	5.0	0.105	0.082	-0.072	0.159
1990	7	15	48087.128030	-.02270	0.00028	CER	HAD	4	3.3	0.090	0.064	0.003	0.384
1990	7	16	48088.191202	-.02418	0.00020	CER	HAD	10	4.0	0.201	0.183	-0.009	0.229
1990	7	17	48089.135053	-.02557	0.00025	CER	HAD	3	1.7	0.172	0.098	0.395	1.086
1990	7	18	48090.120577	-.02670	0.00018	CER	HAD	4	2.4	0.160	0.116	0.041	0.661
1990	7	18	48090.130878	-.02666	0.00022	CER	TRA	3	1.6	0.071	0.055	0.038	0.992
1990	8	9	48112.497156	-.09926	0.00033	HAL	HAD	4	3.6	0.382	0.062	-0.455	0.435
1990	8	10	48113.455211	-.10106	0.00030	HAL	HAD	3	3.2	0.214	0.069	-0.418	0.795
1990	8	12	48115.056175	-.06306	0.00027	CER	HAD	3	3.8	0.132	0.039	0.101	0.470
1990	8	14	48117.125396	-.06682	0.00032	CER	HAD	3	2.8	0.159	0.116	0.196	0.633
1990	9	10	48144.444673	-.15692	0.00032	TLR	HAD	3	3.1	0.199	0.054	0.281	0.430
1990	9	12	48146.480056	-.15981	0.00022	TLR	HAD	4	2.7	0.066	0.035	0.013	0.256
1990	10	10	48174.140747	-.18719	0.00035	CER	HAD	4	5.0	0.194	0.092	-0.220	0.337
1990	10	11	48175.471009	-.21692	0.00017	TLR	HAD	5	2.8	0.102	0.054	0.046	0.340
1990	10	27	48191.842839	-.22671	0.00071	CER	HAD	5	1.5	0.371	0.118	0.644	0.884
1990	11	6	48201.284404	-.25183	0.00013	CER	HAD	5	1.7	0.144	0.141	-0.038	0.627
1990	11	6	48201.308674	-.25195	0.00026	CER	TRA	3	1.5	0.138	0.069	-0.126	0.970
1990	11	7	48202.289864	-.25387	0.00012	CER	HAD	7	3.4	0.119	0.085	0.193	0.414
1990	11	8	48203.302626	-.25601	0.00013	CER	HAD	5	9.4	0.172	0.077	0.052	0.502
1990	11	23	48218.742585	-.29146	0.00056	CER	HAD	6	2.3	0.144	0.074	0.137	0.583
1990	11	27	48222.885112	-.30278	0.00017	CER	HAD	10	4.9	0.264	0.135	0.293	0.286
1990	11	29	48224.976213	-.30855	0.00013	CER	HAD	11	5.0	0.189	0.151	0.189	0.273
1990	12	7	48232.146427	-.32521	0.00018	CER	HAD	7	7.5	0.218	0.165	-0.175	0.265
1990	12	7	48232.175300	-.32536	0.00049	CER	TRA	3	3.0	0.200	0.023	0.210	0.390
1990	12	8	48233.186886	-.32788	0.00021	CER	HAD	7	6.6	0.295	0.205	-0.145	0.221
1990	12	8	48233.199723	-.32794	0.00029	CER	FRM	3	5.2	0.394	0.100	-0.432	0.366
1990	12	8	48233.459679	-.33963	0.00037	TLR	HAD	3	2.6	0.234	0.003	-0.256	0.541

1990	12	9	48234.516466	-.34232	0.00039	TLR	HAD	5	2.3	0.124	0.093	-0.085 0.341
1990	12	22	48247.757964	-.35665	0.00049	CER	HAD	5	1.9	0.154	0.074	0.272 0.849
1990	12	23	48248.755280	-.35890	0.00046	CER	HAD	3	2.4	0.242	0.149	-0.127 0.608
1990	12	23	48248.757402	-.35898	0.00050	CER	FRM	3	2.4	0.182	0.142	0.152 0.674
1990	12	27	48252.815080	-.36881	0.00049	CER	HAD	4	2.4	0.251	0.158	-0.207 0.313
1990	12	28	48253.896801	-.37128	0.00027	CER	HAD	8	3.6	0.213	0.062	0.276 0.233
1990	12	28	48253.925913	-.37114	0.00041	CER	FRM	3	2.8	0.054	0.004	0.009 0.485
1991	1	18	48274.695357	0.58458	0.00052	CER	HAD	4	1.9	0.107	0.095	0.095 1.148
1991	1	20	48276.736956	0.57963	0.00034	CER	HAD	5	3.1	0.205	0.177	0.003 0.656
1991	1	21	48277.688143	0.57697	0.00047	CER	HAD	3	3.3	0.349	0.058	0.394 0.438
1991	1	22	48278.780508	0.57456	0.00012	CER	HAD	11	7.1	0.292	0.091	0.199 0.202
1991	1	22	48278.812851	0.57450	0.00020	CER	FRM	3	3.9	0.196	0.007	-0.199 0.484
1991	1	23	48279.767196	0.57243	0.00010	CER	HAD	14	8.7	0.243	0.155	0.036 0.182
1991	1	23	48279.819450	0.57229	0.00017	CER	FRM	6	5.6	0.171	0.083	-0.072 0.313
1991	1	23	48279.835644	0.57221	0.00022	CER	TRA	5	4.5	0.373	0.065	0.436 0.457
1991	1	24	48280.801890	0.57023	0.00013	CER	HAD	8	9.1	0.139	0.116	-0.126 0.430
1991	1	25	48281.868061	0.56833	0.00012	CER	HAD	13	9.1	0.241	0.196	0.080 0.230
1991	1	25	48281.898274	0.56847	0.00026	CER	FRM	3	5.4	0.259	0.233	-0.248 0.609
1991	1	27	48283.022176	0.56662	0.00019	CER	TRA	3	1.8	0.291	0.181	-0.510 0.957
1991	1	27	48283.024554	0.56647	0.00010	CER	HAD	8	4.4	0.232	0.099	0.203 0.289
1991	1	27	48283.033208	0.56647	0.00016	CER	FRM	4	3.1	0.175	0.048	0.131 0.522
1991	1	27	48283.990411	0.56497	0.00036	CER	FRM	3	7.2	0.074	0.058	0.145 1.118
1991	1	27	48283.990741	0.56480	0.00011	CER	HAD	10	8.6	0.327	0.188	0.196 0.432
1991	2	5	48292.202562	0.54557	0.00040	CER	HAD	5	3.9	0.446	0.202	-0.401 0.311
1991	2	22	48309.130377	0.50758	0.00027	TLR	HAD	3	2.7	0.277	0.091	0.180 0.375
1991	2	22	48309.790811	0.50981	0.00052	CER	HAD	3	3.0	0.115	0.101	0.016 0.454
1991	2	23	48310.896127	0.50762	0.00028	CER	HAD	5	2.5	0.227	0.050	0.036 0.506
1991	2	24	48311.928797	0.50573	0.00009	CER	HAD	21	8.2	0.175	0.168	0.075 0.151
1991	2	24	48311.983070	0.50594	0.00018	CER	FRM	6	2.7	0.401	0.183	-0.236 0.554
1991	2	25	48312.976411	0.50346	0.00009	CER	HAD	18	7.8	0.166	0.127	-0.089 0.165
1991	3	20	48335.732758	0.45331	0.00049	CER	HAD	3	1.8	0.324	0.190	0.641 0.968
1991	3	27	48342.979229	0.43856	0.00020	CER	HAD	7	4.9	0.072	0.070	-0.007 0.298
1991	4	19	48365.823215	0.39121	0.00012	CER	HAD	7	2.8	0.098	0.091	0.060 0.503
1991	4	21	48367.867202	0.38724	0.00019	CER	HAD	8	3.8	0.164	0.102	-0.036 0.421
1991	4	21	48367.888531	0.38733	0.00027	CER	FRM	5	2.4	0.120	0.087	-0.054 0.787
1991	6	4	48411.447729	0.27116	0.00058	TLR	HAD	4	1.6	0.209	0.053	-0.260 0.651
1991	7	3	48440.114438	0.25857	0.00031	CER	HAD	7	3.0	0.233	0.194	-0.017 0.278
1991	8	1	48469.107172	0.22249	0.00026	CER	HAD	7	4.0	0.196	0.175	-0.093 0.256
1991	8	2	48470.170478	0.22098	0.00020	CER	HAD	8	6.8	0.120	0.082	0.089 0.210
1991	8	3	48471.109866	0.21974	0.00016	CER	HAD	11	4.1	0.152	0.121	-0.144 0.300
1991	8	4	48472.048138	0.21876	0.00016	CER	HAD	4	1.7	0.515	0.357	1.068 1.130
1991	10	3	48532.218850	0.10371	0.00017	CER	HAD	7	5.4	0.165	0.144	0.095 0.315
1991	10	4	48533.188008	0.10117	0.00027	CER	HAD	4	2.0	0.180	0.055	-0.353 1.189
1991	10	30	48559.437528	0.00676	0.00027	TLR	HAD	4	2.1	0.227	0.112	0.131 0.682
1991	11	1	48561.211419	0.03785	0.00018	CER	HAD	6	4.3	0.264	0.078	-0.069 0.272
1991	11	25	48585.119529	-.02069	0.00010	CER	HAD	10	8.3	0.272	0.079	0.032 0.216
1991	11	26	48586.187223	-.02345	0.00014	CER	HAD	7	8.7	0.221	0.240	0.013 0.272
1991	11	27	48587.478643	-.05667	0.00019	TLR	HAD	6	3.7	0.174	0.108	0.011 0.229
1991	11	28	48588.134538	-.02910	0.00033	CER	TRA	4	2.8	0.199	0.069	0.267 0.530
1991	11	28	48588.153950	-.02932	0.00012	CER	HAD	10	6.2	0.178	0.095	-0.052 0.193
1991	11	29	48589.198370	-.03273	0.00024	CER	HAD	6	3.5	0.205	0.093	-0.061 0.243
1991	11	30	48590.196032	-.03578	0.00028	CER	HAD	5	3.0	0.109	0.013	-0.213 0.380
1991	12	1	48591.238169	-.03878	0.00022	CER	HAD	9	3.6	0.149	0.084	-0.101 0.270
1991	12	13	48603.719508	-.06915	0.00063	CER	HAD	4	1.5	0.162	0.083	0.147 0.247
1991	12	14	48604.846909	-.07196	0.00027	CER	HAD	5	3.2	0.119	0.108	0.054 0.516
1991	12	14	48604.848439	-.07189	0.00036	CER	FRM	3	2.2	0.135	0.123	-0.096 0.698
1991	12	15	48605.094711	-.09685	0.00054	TLR	HAD	3	2.5	0.911	0.265	0.819 0.615
1991	12	15	48605.805842	-.07471	0.00014	CER	HAD	11	5.3	0.203	0.134	0.184 0.160
1991	12	16	48606.736376	-.07694	0.00034	CER	HAD	4	3.3	0.217	0.125	0.185 0.390
1991	12	17	48607.784719	-.07985	0.00034	CER	HAD	4	2.8	0.171	0.143	0.139 0.322
1991	12	26	48616.197104	-.09968	0.00028	CER	HAD	5	3.2	0.370	0.143	-0.307 0.253
1991	12	28	48618.214299	-.10479	0.00027	CER	HAD	4	4.1	0.361	0.036	-0.276 0.274
1991	12	29	48619.239149	-.10771	0.00029	CER	HAD	7	3.6	0.231	0.076	0.203 0.240
1991	12	30	48620.234282	-.11006	0.00039	CER	HAD	4	2.4	0.319	0.091	0.245 0.382

1992	1	12	48633.808400	-.14134	0.00053	CER	HAD	4	1.6	0.208	0.125	0.093	0.852
1992	1	13	48634.801829	-.14403	0.00012	CER	HAD	12	6.2	0.161	0.149	-0.077	0.164
1992	1	15	48636.907514	-.14928	0.00013	CER	HAD	6	6.6	0.306	0.236	-0.104	0.273
1992	1	16	48637.917730	-.15155	0.00016	CER	HAD	5	5.7	0.177	0.090	-0.131	0.297
1992	2	8	48660.757023	-.21179	0.00036	CER	HAD	3	1.8	0.081	0.048	-0.070	0.929
1992	3	10	48691.784111	-.28843	0.00042	CER	HAD	4	2.3	0.157	0.134	0.214	0.958
1992	3	12	48693.928185	-.29364	0.00013	CER	HAD	4	2.0	0.089	0.070	-0.153	0.736
1992	3	14	48695.937944	-.29868	0.00026	CER	HAD	5	2.9	0.313	0.149	-0.564	0.450
1992	3	16	48697.900906	-.30546	0.00016	CER	HAD	7	5.7	0.406	0.121	-0.390	0.215
1992	4	10	48722.824697	-.37229	0.00043	CER	FRM	3	3.4	0.299	0.046	0.303	0.668
1992	4	10	48722.873044	-.37254	0.00011	CER	HAD	11	6.1	0.146	0.081	0.010	0.233
1992	4	11	48723.842062	-.37519	0.00014	CER	HAD	8	5.3	0.100	0.064	-0.058	0.193
1992	4	12	48724.862619	-.37801	0.00024	CER	FRM	6	5.2	0.535	0.132	0.434	0.237
1992	4	12	48724.884617	-.37819	0.00027	CER	TRA	4	3.8	0.200	0.133	0.020	0.321
1992	4	12	48724.906360	-.37837	0.00013	CER	HAD	10	5.6	0.095	0.079	-0.088	0.205
1992	4	14	48726.929809	-.38563	0.00068	CER	HAD	4	2.2	0.273	0.063	-0.025	0.433
1992	4	22	48734.124958	-.40451	0.00028	CER	HAD	7	3.0	0.069	0.065	0.028	0.200
1992	5	9	48751.859156	-.44453	0.00019	CER	HAD	6	3.2	0.199	0.147	-0.267	0.413
1992	5	10	48752.879815	-.44721	0.00015	CER	HAD	7	4.5	0.103	0.100	0.005	0.280
1992	5	11	48753.144148	-.45921	0.00036	TLR	HAD	4	2.6	0.433	0.141	0.160	0.453
1992	5	12	48754.145225	-.46209	0.00048	TLR	HAD	4	1.9	0.360	0.056	0.255	0.320
1992	5	13	48755.900189	-.45506	0.00017	CER	HAD	8	4.7	0.152	0.117	0.102	0.180
1992	5	14	48756.989125	-.45771	0.00057	CER	HAD	5	1.6	0.226	0.168	0.291	0.619
1992	6	8	48781.859049	-.50409	0.00023	CER	HAD	6	3.1	0.110	0.047	-0.194	0.383
1992	6	21	48794.138611	-.52112	0.00029	CER	HAD	6	3.2	0.239	0.115	0.237	0.217

During all of our efforts under this Grant we continued to build upon that which had already been established. We continued near-real-time earth orientation computations, co-operating with colleagues around the world in support of the International Earth Orientation Service. On-going efforts on this front were those needed to make the system more responsive, more precise, and more effective.

We continued to monitor LAGEOS orbit prediction capabilities (especially that which was being performed at UT/CSR and the Royal Greenwich Observatory, for example) with respect to real-time, on-site Earth orientation parameter computations. We also kept abreast, along with our colleagues at UT/CSR, of the ways in which the two Soviet Etalon targets might be used to produce better Earth orientation products. Along with Mr. Richard J. Eanes we attempted to determine the best time and methods to attempt a joint, all-optical reduction of earth orientation parameters using both artificial satellite and lunar data.

Finally, we continued our examination of combining the LLR observations from the presently active lunar stations (and any others which would come on line from time to time) and investigated a completely independent three-dimensional solution for Earth orientation, if suitable improvements in lunar data volume and density were to become available to warrant such an effort.

Conclusions

We believe that the efforts which we have made toward our original NASA Grant NAG5-754 goals have been substantial and well in keeping with the spirit of the original plans set down in the original proposal. We feel that this effort merited the continuation of funding which they had received through the final months of Crustal Dynamics Project activity, to assure that the final and most ambitious of the goals, i. e., the on-site, joint, real-time production of earth orientation parameters using both lunar and LAGEOS (and Etalon) laser ranging data and the coordinated multi-lunar station results, can be brought to fruition.

Our principal effort during the closing months of this Grant was to continue our LLR-based input into the International Earth Rotation Service (IERS) as we make a transition to other funding sources.

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